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CONTENTS:

	PAGE
Fire Risk Rules	317
Electric Blow-pipes (*illustrated*)	321
Municipal Lighting	322
The Relative Cost of Gas and Electricity in Cotton Mills ...	325
Researches on the Action of Electricity upon certain Gases...	326
The Electro-Magnet	327
Polarisation of the Earth by Heavy Currents (*illustrated*) ...	333
Notes	333
City Notes, &c. :—	
The Electric and General Investment Company ...	338
Traffic Receipts	338
Share List of Electrical Companies	338
Wine and Electricity	339
Electricity at the American Association	339
Electrical Census Taking	340
British Association for the Advancement of Science :—	
Recent Determinations of the Absolute Resistance of Mercury (*illustrated*)	340
Discussion—On Alternating Currents in Relation to the Human Carcase and on Fire Insurance Rules	344
Testing Iron (*illustrated*)	345
The Effect of Oxidation on the Magnetic Properties of Manganese Steel (*illustrated*)	346
The Lineff Electric Tramway	347
Column-Printing Telegraph	348
The Effect of Direct and Alternating Pressures on the Human Body	348

FIRE RISK RULES.

"SUCH rules should be based on the deductions of experiment and the teaching of experience. They should give the utmost freedom of action and encourage progress. They should contain the minimum that is necessary, and this should be strictly enforced. Above all, these rules should be in accordance with the general principles which regulate all successful engineering constructions. For example, if we consider such familiar, but different structures as a locomotive engine, a steamer, or a bridge, we observe that there is no absolute safety in any one of them. Each has been perfected, not by directing the mind to a particular class of facts, but by a judicious compromise between many conflicting necessities, by giving neither more nor less than a just measure to each requirement, and in each case, all this has had to be done with due economy and limited means. In this spirit all fire insurance regulations should be framed."

This is the concise manner in which Mr. Wilson Hartnell summed up the requirements of fire risk rules and regulations when, before the British Association, he pointed out some much-needed amendments in those now existing; and it is on his admirable paper, and the correspondence on the same subject in the *Times*, which has extended in a fitful manner over a period of some weeks, that we purpose offering a few comments. This, however, will not be so much with a view of suggesting any technical alterations, but rather from a desire to bring about the necessary feeling of compromise amongst the conflicting interests which now render the proper carrying out of electric lighting installations a matter of no small concern.

Mr. Hartnell condemns any attempt on the part of insurance companies to determine a fixed current density in conductors as "useless, vexatious, and scientifically wrong," and on this point we cordially agree with him, and would urge upon the various companies' technical experts not only the advisability, but the absolute necessity, of substituting for the clauses dealing with the sectional area of conductors others based upon scientific principles.

When the subject of insulation is dealt with, it is not quite so easy to follow the ideas which presented themselves to the author's mind. That the chief object of electric light insulation is safety, and that this should continue for as many years as possible, is doubtless the view entertained by all electrical engineers; but Mr. Hartnell seems likely to be misunderstood when he says that he considers durability of far more consequence than high insulation. The term "high insulation" is, of course, a relative one only; but surely that very durability upon which so much stress is laid depends upon good and, probably, according to the material used, high insulation? It, therefore, seems to us that Mr. Hartnell is in error in trying to dissociate the one from the other, although we concur in his opinion respecting the advantages of naked wires on insulators. So far as his distrust of vulcanised India-rubber goes, we would not like to say that it is entirely untenable; on the other hand, evidence as to its superiority over all other kinds of insulation for electric light leads could doubtless be produced in abundance.

The question as to what wires will pass the insurance companies is perhaps the most vital point of all for the contractor, and a letter which appears in our correspondence columns is only one of numerous complaints of a similar nature which have reached us from many quarters.

So far as specifying the insulation resistance per mile is concerned, there should be no difficulty whatever in this, nor should the question of dry or wet weather enter into the matter at all. All wires covered with India-rubber, gutta-percha, okonite, Callender's bituminous compound, or what not, are tested after an immersion for a given time, usually 24 hours, in water at a temperature of, generally 75° Fahr. It is necessary, owing to the effects of temperature upon the insulating materials to reduce the dielectric resistance to a standard; and in telegraph work, whether underground or submarine, it is always taken at 75°.

What the result of testing for insulation turns out to be after the installation is completed depends not so much upon the wire, which *per se* should be just as good as when it left the manufacturers, as upon the number and nature of the apparatus in circuit, which include lamps, switches, cut-outs, joints, &c., of various kinds. Naturally the wire, through lapse of time, will not remain in the same excellent condition as when first erected, for only under water will India-rubber and gutta-percha retain their insulating properties for many years unimpaired.

The controversy in the *Times* was commenced by Major Flood Page, who, in reply to a question as to the rules which were best to adopt for wiring houses in a small provincial town, answered that he could only say that some fire insurance offices followed one set of rules, others made their own, others had none, some trusted to inspection of each risk, and that, in the interests of the public, of the contractors, and of the offices themselves, it was most earnestly to be desired that one set of rules should be adopted by all the fire insurance offices.

Furthermore, this gentleman, after a careful examination of the rules of the Phœnix office and of the Institution of Electrical Engineers, and also of the special rules of ten different fire offices, concluded that they contained no crucial difference, nor any disagreement in principle, and, while founded on the Phœnix model, the variations were mere matters of detail, none of which, so far as the gallant Major could see, made the offices which introduced the changes any safer or better for the introduction. In conclusion, he advocated the adoption of Mr. Musgrave Heaphy's classical compilation on a variety of grounds, one being that "notwithstanding the number of years these rules have been in use, not a single instance of fire has occurred from any electrical installation placed up in compliance with them." Prof. Silvanus Thompson and Mr. C. H. W. Biggs took up the cudgels in the same cause; but two gentlemen, who have had much practical experience on a subject which their opponents could only treat theoretically, brought their guns to bear upon the Phœnix rules, and knocked them considerably out of shape, although not beyond recognition.

Mr. Verity explained how a serious effort was made to compile standard rules by the Institution of Electrical Engineers some time ago, but the rules then devised never commanded general respect and gradually lapsed owing to the action of certain fire-office surveyors, who throughout maintained that it was for them to satisfy themselves of the risks they took; that they were entitled to take whatever steps they thought necessary for the protection of their offices; and that they could not recognise rules laid down by an institution in no way associated with them financially in their risks. "But," says Mr. Verity, "it is distinctly wrong to say that electric light rules concern the fire offices only. They concern the electric supply companies, as they also must be satisfied with the efficiency of house wiring before they connect it to their system; they concern the electrical contractor, who could do his work more speedily and at a lower rate if uniform requirements were insisted on; and they greatly concern the house occupier who wants to be left in peace, feeling that when such work has once been done he will not be disturbed again. Besides the variety of rules mentioned by Major Page as being issued by fire offices, each electric supply company has also its own set of rules which must be complied with, It may be asked, Why should a supply company require rules also, and why is the fire-office inspection not considered sufficient? I fear the reply must be that although such inspection is often carefully made, yet in many cases it is very perfunctorily performed. Moreover, fire office inspection of electric work usually deals solely with the quality of material, the system of safety fuses, switches, &c., and it would be quite a novelty for any fire-office surveyor to be seen with instruments for accurately testing as to the efficiency of the work, and yet this is just what a supply company requires."

Mr. A. A. Campbell Swinton alluded to Major Flood Page's letter in a grimly sarcastic vein:—"Among persons competent to judge, there is now no question that, given proper appliances and good workmanship, the electric light is by far the safest of all illuminants, but, at the same time, it must be confessed that the statement that no fires have occurred where the Phœnix rules have been thoroughly followed is a very safe one, as it is, at all events, open to doubt whether there ever has yet been an installation carried out in entire accordance with these rules."

Both gentlemen are agreed that Mr. Musgrave Heaphy has undoubtedly been the means of bringing about the present high standard of electrical work, and his rules must form the basis of future work in this direction. But the objections that have been from time to time raised to the Phœnix rules are that they are too many and diffusive; that they leave too much to the discretion of the surveyor, whom, from the vast amount of work, it is impossible to so frequently consult; that some of the rules are unnecessary and not desired by other leading offices; and that some of the details required simply tend to unnecessary expense, without adding to safety.

Moreover, each edition becomes more and more voluminous, and this seems likely to go on *ad infinitum*.

It appears, therefore, that what is now desirable is a set of rules which will meet the approval of both insurance and electrical supply companies, and also the needs of wiring contractors. It seems on the face of it unnecessary that supply companies should require a set of rules for their own protection, but that this is at present the case is well known, and for obvious reasons they must themselves decide whether to supply current to a house or not, even if it has passed the fire office inspectors. The insulation question is a very important one for companies supplying on the low tension system, as a bad leak in one house may interfere with the supply of a whole district, a drawback which does not enter into the transformer method, so long as the primaries are kept free from the secondary coils. It will be readily seen then that although a fire office takes the risk of the house in which a conflagration

happens to occur, still the supply company has a heavy responsibility; this, however, might be merged into the insurance companies upon the adoption of new standard rules. Now, to effect this object, there is only one obstacle to overcome, and that is to bring Mr. Heaphy to take a reasonable view of the situation. He was in the beginning guide, philosopher, and friend to the electric lighting industry; now he is the stumbling-block.

A practical committee, composed mainly of men who have had the advantage of experience to guide them, is required, but it should not contain more than eight members, half that number representing the fire offices, and the others selected from the contractors and supply companies. More than these would lead to waste of time and quibbling, and in the end the result would, like Prof. Fitzgerald's famous mathematical paper, "An episode in the life of $J" = 0$.

Now we may take it that the fire offices are quite as anxious as the contractors to see one set of rules adopted, and, generally speaking, they will not care from whence they may emanate, so long as they fulfil certain conditions. No one wishes to deprive the "Phœnix" of the credit due to them in the matter, indeed, that would be impossible; but we and others have objected to Mr. Heaphy's rules as unsuitable from a business point of view, on account of their vagueness in important points, leading to unnecessary correspondence and interviews.

A very laudable attempt was made last year by the Fire Offices' Committee to issue an official set of rules which, we believe, would have given satisfaction to all concerned, but owing to the factious opposition of a few, it was deemed advisable to let the matter rest for a time, and thus we have drifted into the present unsatisfactory state of things.

Now as to an ideal set of rules. Let us consider them from the fire office point of view. In the majority of fire offices the inspection of electric installations forms but a small portion of the duties of their surveyors, and it is essential that that portion be rendered as light as possible. Hence rules regulating the installation of electrical energy should be definite and precise—in fact, in the form of *must be*, and not *should be*. Limits as to current, spacings, insulation, and the like, should be all clearly defined. Nothing should be left for "approval," and the "inspector" should be eliminated from them. It is quite possible, in our opinion, to draw up a set of rules that shall compel good work, without entering into minute details. Specify for enough copper, well insulated, and the proper jointing and carrying of conductors; state the principles governing the construction and mounting of switches and cut-outs; prohibit their being placed in positions where, if they go wrong, they can do harm; then, if the total insulation of an installation is satisfactory, we may rest content. Above all, do not harass the contractor with mere fads and fancies. Reasonable security against fire can be attained without unnecessarily adding to the cost of wiring, and thus retarding the more general introduction of what is, after all, the safest light to be had. The insurance companies' task will in future be much simplified by the Board of Trade regulations. They need now concern themselves only with the house work. More latitude should be allowed in wiring off a direct continuous current supply, as against alternating transformer systems. With the former one well-known company had no trouble, whereas with the latter it has had a good deal.

The present agitation will do good, and we hope lead to some satisfactory results this autumn. Upon one thing, however, everybody concerned may rely. The leading fire offices will not have the Phœnix rules thrust upon them in their present garb—Prof. S. Thompson notwithstanding! Let that be clearly understood.

To bring the matter officially before the representatives of the fire offices, we would suggest a letter on the subject being addressed to the Secretary of the Fire Offices' Committee, Watling Street, from, let us say, the Electrical Section of the LondonChamber of Commerce?

There is no need to trouble the Institution of Electrical Engineers further; there are certain broad principles common to all systems of electric lighting, but we feel inclined to agree with a *gas* contemporary that electricians will have to share the fate of gasfitters in a similar event, and meet every fresh case on its own merits. It cannot be a difficult task to settle the principal desiderata of safe electric light wiring; but exceptional cases are certain to arise from time to time, which cannot be dealt with by hard-and-fast rules. The project of employing the Institution of Electrical Engineers, or the Board of Trade, or any other outside body to draw up a code of fire rules, falls to the ground the moment it is perceived that since the Fire Offices would have to pay the damage, they must have the last word as to what precautions they would be satisfied with before issuing a policy.

A last word on the duties of inspectors. Can it be a satisfactory condition of affairs to know that the representative of a fire office may also be a consulting engineer even if he has no direct interest in any electrical supplies? We believe the inspectors of Lloyd's, for instance, devote the whole of their time to the duty of examining ships, and do not practise as technical advisers to the very people with whose vessels they may have to find fault. In electrical engineering, however, possibly because the business is yet but in its infancy, we have known instances of fire inspectors acting as censors of the work and materials advised by them, as experts, to be employed; and consulting engineers acting as contractors to their own clients; in fact, as they cannot fill up their time profitably in one branch, there is a tendency to combine all. These things should not be passed unnoticed, and the pages of the REVIEW are open to any of our correspondents to suggest plans by which the whole fraternity may yet become a happy family.

Refusal of a Concession for Electric Tramway.

THE Thomson-Houston Company has experienced a rebuff on the part of the Bremen Town Council. One of the reasons assigned for the refusal of the concession

for a projected line from the Rathhaus to the Buergerpark was said to be due to the very unsatisfactory working of the electric tramway at the Bremen Exhibition. The noise occasioned by the cars was considered unbearable, and another objection was raised against the sparks or "flashes of lightning" between the wheels and rails forming the return circuit. Similar complaints reach us from Italy anent another American system, and it appears that people on the Continent of Europe are not inclined to put up with nuisances which our American cousins tolerate. Toothed wheel gearing must sooner or later develop that rattling noise which, however natural to a machine shop, will never be appreciated in a public conveyance. Visitors to Blackpool are ever complaining of the noise occasioned by the electric tramcars, and these are fitted with the best kind of chain gearing, as are also those of Barking Road, with another noisy sort.

The Oldest Electric Tramway.

THE Lichterfelde Electric Railway, the oldest in the world, has been extended to the Potsdam Railway station and opened for traffic.

Duty on Electricity.

AMERICANS, more than any other nation, enjoy the privilege of paying duty for most things which cross their frontier. Hitherto electricity by means of submarine cables has entered free of duty; this was for telegraphic purposes only, but the probability is that this "imponderable matter" may, in future, be taxed if "imported" for other uses. There exists, according to the *New York Herald*, an enterprise called the "Cataract Construction Company," which has for its object the utilisation of the power of the Niagara Falls. This company having learnt that some Canadian parties are endeavouring to organise opposition for the construction of works on the Canadian side, with the intention of transmitting the power to the American side, have asked the Conference Committee on the Tariff Bill to insert a clause taxing the conveyed energy at the rate of $5 per horse-power. It is not stated whether this is for a horse-power per minute or per annum; anyhow, the question is an interesting one, and we wonder whether the vigilant U.S. Custom House officials will stop the current at the frontier for the purpose of examining its *quality*, since the notion of two kinds of electricity still exists in certain quarters, or whether it will be passed through a meter kept by the excise officers?

Paper Tubes for Underground Work.

PIPES for gas, water and electric cables, made of paper, have recently been exhibited in Vienna. The width of the paper is equal to the length of a given pipe. The paper runs first through molten asphalt and is rolled upon a mandril of wood, the size of which determines the inside diameter of the pipe. When cool, the mandril is removed, and the inside of the tube covered with a kind of enamel, the composition of which is kept secret. The outside is covered with a bituminous lacquer and sand. It is stated that a pipe of 2 centimetres thickness of material stands an internal pressure of 1,000 kilogrammes.

Curious Reasoning.

AN electrical contemporary which, last week, devoted a leader to prophesying the speedy demolition of the B.A. for the Advancement of Science, unless reforms were adopted to meet the wants of the times, commences in the following contradictory manner:—"The afternoon of Saturday was very fine in Yorkshire; and the meeting of the British Association may therefore be considered to be a success, since members had every opportunity for enjoyable excursions." Just as one swallow makes a summer, so a fine Saturday half-holiday sets the seal of success upon what the *Evening News and Post* calls a moribund association.

Delay in Applying the Telegraph Scheme.

WE have already laid the general terms of the new telegraph scheme before our readers. Though some months have elapsed since its existence was made public, it is surprising to hear that it is not yet in general operation at the Central Telegraph Office. Whatever may have led to this extraordinary delay, it is to be hoped that such points as a fairer system of awarding sick pay to first and second class clerks, the question of a month's annual leave to the former body, and the unsettled question of the improvement of the position of senior clerks, will have been found to have received that full measure of recognition which their importance demand.

Elmore's French Patent Copper Depositing Co., Ltd.

A FINANCIAL contemporary writing on this subject makes the following apposite remarks:—"The game that has been played is undoubtedly a clever one, but its success does not inspire us with confidence in the future of the companies. The mere fact that each parent concern has created sub-companies, and received substantial sums from them is sufficient explanation of the premium at which the shares of each of those concerns stand, but what has any one of them *earned*, and what have the off-shoots accomplished in the way of genuine business? It stands to reason that these fresh issues of capital cannot go on for ever. The time must come when the *bonâ fides* of each of them, and the commercial value of the Elmore process will be put to the proof, and it is our duty to keep this fact before our readers. Our own opinion is that the invention of the Messrs. Elmore is worth money, but not so much money as the wire pullers have obtained for it; not as many pence as they have been paid shillings, and we do not for one moment believe that the demand for absolutely pure copper is sufficient to return a dividend of 1 per cent. upon the capitalisation of the companies we have enumerated. Were there but one—Elmore's Patent Copper Depositing Company, for instance—it might be a pronounced success; but as it is, we feel convinced the result will be a disastrous one for the shareholders. It must be remembered that the aggregate capital employed is £820,020, made up as follows:—

Elmore's	Foreign and Colonial	£120,000
,,	Copper Depositing	200,000
,,	Wire Manufacturing	300,020
,,	French Patent	200,000
		£820,020

To pay 10 per cent. upon that amount will require £82,000 per annum." It is possible, however, that Sir W. Thomson's paper to which we alluded last week on p. 287, may create a great demand for perfectly pure copper.

Accumulator Tramcars.

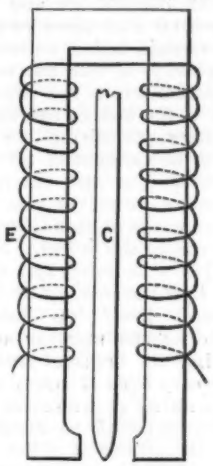
HOW is it that with twelve cars the Birmingham Central Tramways Company run only five of them? Also how is it that the General Electric Power and Traction Company, with six cars at Barking Road, have only three and sometimes only two running?

ELECTRIC BLOW-PIPES.

By A. M. TANNER.

MY attention has been drawn to an illustrated article in the *Electrical World* of August 23rd, 1890, on welding with the electric arc. This article reviews certain inventions of C. L. Coffin on the above-entitled subject, and says that "the fundamental principle involved therein can be called that of an electrical blow-pipe;" furthermore, it is stated that the idea of handling the electric arc as one would a blow-pipe with a magnetic blast instead air, is certainly a very beautiful and ingenious application of theory. From this it would appear that Mr. Coffin, or the writer of the article in the aforesaid journal, is without knowledge of the electric blow-pipes of Werdermann and Jamin, and the fact that the action of electro-magnets upon the electric arc has frequently been studied, notably, by Quet (see *Comptes Rendus*, of French Academy of Sciences, Vol. XXXIV., A.D. 1852, page 805). Quet states that Davy was the first to experiment upon the voltaic arc with magnets, and that Despretz and others had also studied the same phenomenon. In referring to his own experiments, he says:—

"I caused a very powerful electro-magnet, made by Rhumkorff, to act upon the Davy arc, and I transformed the column of light into a long rushing point of an intense heat, and similar to the blow-pipe flame. I obtained this result by placing the carbons perpendicularly to the common axis of the electro-magnet coils. In order to explain my idea, I will suppose this axis to be horizontal, the carbons vertical, and their points placed between the neighbouring poles of the apparatus. In these conditions, instead of a vertical column of electric light a horizontal point is formed (dard) perpendicularly to the axis of the coils, just as when the blast of a blow-pipe is directed upon a flame. The analogy is so complete that, by reason of the noise produced by the arc, it appears as if some one were blowing. The light of this point has neither the whiteness or dazzling character of the electric column it displaces; nevertheless, its heat is very great, because it is capable of melting platinum. Because of this last-mentioned property, and the form taken by the arc, it appears to me that this kind of *electro-magnetic blow-pipe* can be usefully applied in the arts. The electric point (*dard électrique*) is remarkable for its length. In my experiments, it was eight or ten times more than the maximum length of the luminous column. Quet also states that the carbons can be placed at an angle, or one at the side of the other, in which case the electric point is formed laterally and parallel to the carbons. It will readily be perceived that Quet foreshadowed Coffin's process, in which the arc is formed between two converging carbon pencils and is blown downward upon the metal surfaces to be heated by the influence of an electro-magnet. An arrangement of parallel carbon electrodes (as in Jablokoff candle) and electro-magnet is shown by Richard Werdermann in his English patent, No. 1,438, dated April 24th, 1874, for a method of cutting rock or stone, &c. I can do no better than to quote the entire description of this patent, bearing upon an electric blow-pipe, particularly as the article on Coffin's welding process states that an air-blast is sometimes used for deflecting the arc. This is also an idea disclosed by Werdermann, as will be seen from the following abstract of the description found in the patent, viz.:—"When the rock is very hard, as porphyry, granite, gneiss, and the like, I prefer to use an electric blow-pipe. Fig. 3 is a plan of an apparatus for carrying this part of my invention into effect, and fig. 4 is a front view of the same. In this apparatus the carbon points, *g*, of the electric light are fixed on a suitable handle or frame provided with pinions, *h*, and racks, h^1, to regulate their distance. I blow through the voltaic arc over the two carbon points, *g*, a powerful current of air or steam or other suitable vapour or gas. For this purpose I provide a carbon tube, *k*, arranged over the said carbon points, *g*, and provided with an adjusting pinion, *l*, and rack, l^1. The air, steam, or gas is supplied to the said carbon tube by a pipe, *m*. When the blast is in operation through this tube, and the light is burning, the flame of the voltaic arc will produce the effect of a powerful blow-pipe. g^1, g^1, are wires connecting the carbon points with a battery. In fig. 5 I have shown an apparatus in which the carbon points are arranged between the two poles of a powerful electro-magnet, and the blow-pipe is not used. As soon as the light is produced and the electro-magnet set in action, the voltaic arc is repelled and pointed like the flame of a blow-pipe. The heat obtained by the apparatus shown in figs. 3 or 5 is so intense that the hardest granite is thereby not only calcined *but is fused* in a few seconds."



E, Electro-magnet. C, Carbon pencil.

FIG. 5.

Another electric blow-pipe (*chalumeau electrique*) is described by Jamin in the *Comptes Rendus* of the French Academy of Sciences, Vol. 88, A.D. 1879, page 544. After having described an electric lamp with parallel carbons, and the effect of an electro-magnet upon the electric arc, first discovered by Quet, Jamin states:—"The fusion of lime proves that the arc thus projected by a magnetic effect is capable of considerably heating all bodies; it is a genuine blow-pipe, and probably the most powerful of all. I recommend it to chemists and physicists."

The blow-pipes of Werdermann and Jamin, although not specially designed for such purpose, are adapted to be used for the electric welding of metals, since they have parallel electrodes arranged in such a way that the arc can be projected upon surfaces placed beneath the arc. There is another more recent reference to be considered which is also an electric blow-pipe, and is specially designed for welding and soldering metals. The English patent of Bernardos and Olszewsk, dated October 28th, 1885, No. 12,984, describes and illustrates in figure 35, an "Electric Solderer," which has two parallel carbon pencils fastened in a holder and arranged above an anvil on which the work is placed. The anvil is surrounded by a wire coil, so that when the electric current produces the arc between the parallel carbons and flows through the anvil coil, the anvil is converted into an electro magnet "whereby the flame of the arc is drawn to the object to be operated upon."

I think I have satisfactorily shown that Mr. Coffin did not invent the electric blow-pipe. Quet having fused platinum with a so-called "electro magnetic blow-pipe" in 1852, and Werdermann having subsequently applied the same instrument to the cutting and fusion of mineral substances. Du Moncel, the eminent historigrapher of the applications of electricity, says in his work: "I desire to be impartial in my

writings and 'à rendre à César ce qui appartient à César. It is well that this should be observed in this modern age of electricity, and credit bestowed where credit is due.

MUNICIPAL LIGHTING.*

By M. J. FRANCISCO.

THE electric spark that Franklin gathered upon his key lay dormant for years, until from the fires of genius, guided by the finger of science, there flashed forth the electric light. This has been increased and magnified, until to-day America stands as the exponent of this science, with 300,000 arc and 4,000,000 incandescent lamps flashing like meteors across the continent. Thus has science aided nature in lighting up the streets and highways of our native land, from the shores of the Atlantic, across the snowy peaks of the Rocky Mountains, to the golden shores of the Pacific.

This vast industry, requiring an army of over 300,000 men and an investment of $300,000,000, is the result of American genius and enterprise. Truly we may well congratulate ourselves that we are here to-day as the representatives of this science and industry, which is revolutionising the world. Not only has the globe been encircled with telegraph symbols, and the human voice sent flying across space for thousands of miles, but the ocean itself has been studded with electric lights, guiding the mariner across its waste of waters, and flashing its brilliant hues as a welcome beacon upon the weary eyes of many a watching crew, whose vessel was sinking in mid-ocean.

This science, fraught with so much good for mankind, which has put millions of money into circulation and furnished employment to thousands of labouring men and others, is now menaced by men who, posing as economists, desire to use this power for political and other purposes, as well as for their own aggrandisement, regardless of the interest of the masses or the public welfare. The plain English of this movement is municipal control of electric lighting plants.

Who are the great apostles of municipal ownership of electric lighting plants, claiming that municipalities can furnish lights cheaper than private corporations? Mostly visionary, theoretical dreamers. Not one has had a single day's practical experience in the electric lighting business. For example we were treated to a specious article in the New York *Independent*, purporting to come from a professor of Johns Hopkins University. An examination of the article shows at once that the author has no experience or practical knowledge of the business, and proves to be simply a youth from Omaha, Neb., who has been studying there for a couple of years. He is now told to cry monopoly, and this article is the result. These are the persons who are being used by professed economists, wire-pullers, and others as figure-heads; who make statements based upon a state of things that do not exist, and use such statements in contradiction of the actual experience of practical men and the best scientists of this generation, who have not only made the subject a study, but demonstrated the same by testing it every night for years.

If a municipality can sell electricity cheaper than private corporations, why should they not manage all other industries and trades of the country? All cities have large amounts of printing done; why not have the city own and run paper mills and printing offices? also street cars, and own mines and sell coal? They also use immense quantities of stone, building material, &c.; then have them run a marble quarry. The taxpayers use carriages; let the city build these also. And so on with every industry requiring the investment of private capital. If municipalities can save the taxpayer money in controlling and manipulating one industry, why not all? If they can do it cheaper, then every taxpayer would receive the same proportional benefit as is claimed for electric lights.

The great argument used in support of municipal control of lighting plants is a list of cities, with what purports to be accounts of the cost of their electric lights, where over half of the expense of the lights has been charged to other departments. Among these are Bay City, Bangor, Dunkirk, Chicago, Ypsilanti, Topeka and Lewiston.

We will examine a few of the claims made as to the cost of lights in these cities.

The City Superintendent of Bay City, Mich., reported that the cost of the electric lights was only $40 per year. The Council of Bay City appointed a special committee to investigate the expense of city lights, and they submitted a report showing that the city was running 137 lights at a cost of $59.42 each per year, not including taxes, water rates, interest or depreciation. Including interest, 5 per cent. on $35,000, cost of plant, taxes and water rates, 2½ per cent., 10 per cent. depreciation, the cost was $104 per year each lamp, running only dark nights. A short time since, during a thunder shower, the city was left in darkness, because the City Superintendent was afraid of burning out an armature if he ran the lights. A gentleman passing an evening in Bay City recently inquired why they did not have street lights, and the answer was "We do have them," and sure enough, at nine o'clock, they started the lights. Still, the price charged by electric light companies for first-class service, with lights every night, even when obliged to compete with the rival forces of Heaven's batteries, is compared with such service as shown in Bay City.

The city of Bangor claims that the average cost of burning a light each night is 12⅝ cent.; that is $46.23 per year for each lamp. The electrician is paid $78.50 per month, or $942 per year; his assistant receives $520 per year; one lineman is employed at $624 per year; two trimmers at $1,248 for the year—making $3,334 for wages of these men, being $22.82 per lamp per year. They run all night, requiring double lamps and four carbons for each and every day, calling for 1,460 carbons per year each lamp; for these they pay $13 per thousand, and in addition pay 96 cents. per thousand for freight and 5 cents. per thousand for cartage from the freight-house, making cost of carbons $14 per thousand, or $20.44 per lamp per year. Allowing $2.97 per year for oil and waste, we find the amount paid by the city for wages, carbons, oil and waste was $46.23 per lamp per year. This is 12⅝ cents. per lamp per night, just what is claimed as the entire cost to the city for running their lights. The plant cost $35,000, and this does not include anything for the water-power nor for any portion of construction of the dam or cost of its maintenance, or for the station buildings. Interest on $35,000 at 6 per cent., $2,100; depreciation on electric apparatus, 10 per cent., $3,500; broken globes during the year, $130; wall controller burned out, costing $160; 15 lamps broken, repairs costing about $300; damage to mast-arms, repairs costing $100; repairs at station, $500; also $730 paid for coal. Here is $7,520, which is part of the expense of the electric lights charged to some other department, while to get the true cost there must be added to this the repairs to the dam, interest on the cost of the buildings, wages of an engineer when engine is used, cost of new brushes and segments; also taxes and water rent, which the city would receive from a private corporation if running the lights, which, at the lowest estimate, would be over $1,000 per year; thus making a total cost to the city of $15,271.86 for running 146 lamps one year, being $104.59 per lamp, and that, too, with water power all the time except for about six weeks.

The favourite place quoted by advocates of municipal ownership is Dunkirk, N.Y. I herewith give the report of the water commissioners of Dunkirk. As a specimen of expert bookkeeping, and a sample of the way accounts are kept by cities, I recommend the plan

* A paper read before the American National Electric Light Association, August 20th, 1890.

to all electric light men; for, if you are endeavouring to satisfy your constituents or stockholders that electric lights can be run without money and without price, it cannot be excelled. The report reads as follows:—

"PAID ON ACCOUNT OF ELECTRIC LIGHT.

For linemen's salary	$540.00
For fuel	933.24
For supplies	447.60
For labour repairing line	41.42
For repairs on engine and boiler	65.64
For repairs on machinery	99.40
For miscellaneous accounts	14.60
	$2,141.90

"The above statement shows very distinctly that the most sanguine predictions as to the cost of running the electric lights of this city have been more than realised. After a trial of one year and eight months, the machinery and line are in better and more perfect condition than when first started. The cost of our electric light does not exceed 1 cent per hour for each light."

Here we have a report from the city authorities stating that the entire cost to the city of running 55 arc lights one year was $2,141.90.

You will notice one item is repairs on engine and boiler; also one item for fuel, showing that the plant was steam power, and, what is far better, a style of boilers and engine that ran the entire year, starting and stopping at proper times automatically, without anyone to look after them except a man occasionally to make a few repairs—the coal walked into the furnace without assistance, and no one was employed in or about the station, neither did the plant cost the city anything.

Here is a sample of the reports made by politicians and those professed economists, which shows just how reliable they are. Of course, a man of practical experience, and knowing that electric lights do not run without human agency, would look further before accepting such a statement; and when we examine the accounts of the water-works, we find engineers and firemen paid $3,555, supplies $449, general expenses under superintendent $995, miscellaneous accounts $240, superintendent's salary $720, interest on bonds $7,025—making $12,984 additional. Even if only one-third of this is charged to electric lights, we have $4,328 to add to the $2,141, making $6,469 for 55 lights, or $117 each per year. Consistency, thou art a jewel!

Chicago, it is claimed, is the centre of the world, and the only place on this mundane sphere where mortals can be happy, and where life can be spent without thought of money or the hereafter, because their electric lights only cost $73 per year. We admit that Chicago has triumphantly secured the World's Fair, and is now transposing our national air to "Hail, Chicago! happy land." But they have not yet seen the bills for the electric lights, as furnished by the city and used on that occasion. When they do, the city electrician will need to add something more to his stereotyped answers that the cost of city lights "does not include any expenses such as you mention—taxes, water rent, interest on investment, insurance, repairs, depreciation or renewal of plant in general;" neither will it be expedient to charge the wages of the electric light linemen to the fire alarm telegraph department, notwithstanding it works very nicely now, and helps wonderfully to make the cost of an arc light appear small.

Upon investigation of one of their stations of 275 to 300-light capacity, I find that the chief engineer receives $1,200; assistant, $1,030; four firemen, $2,880; six trimmers, $3,240; line tester, $720; three linemen, $2,520; cost of carbons, $3,800; fuel, $12,000; interest, $14,000; depreciation, 2½ per cent., $8,750; oil, waste, repairs, globes, taxes, &c., $7,000—making $57,190 a year expense for running 300 arc lamps, being $190.63 per year per lamp, and this makes no provision for salary of electrician, superintendent, or for armatures burned out, or any accidents or damages. With the linemen's wages charged to the fire alarm telegraph department, we can reduce this $2,520. Now, to what other department do they charge the other expenses to reduce it to $73 per year per lamp.

Ypsilanti, Mich., is the Mecca toward which all advocates of municipal ownership turn their longing eyes, and we are informed that the entire cost of a 2,000 C.P. lamp is $23.61 per year, when the truth discloses the fact that Ypsilanti pays $72 per year, only running 18 nights a month until midnight. Wishing to have the views of the prominent authorities of this wonderfully-managed city, the following questions were propounded, and I give both the questions and answers:—

Q. 1.—With your experience, are you in favour of cities doing their own lighting?—A. No.

Q. 2.—Why? A.—Political preferences and frequent changes of management are too expensive. Incompetent engineers, linemen, and trimmers kept in place by a committee for political or other purposes; poor carbons, lack of attention generally, grounding of wires, breaking of globes, infringement of patents, constant repairs, &c., make this system expensive and an unknown amount till the year expires. *The wear and tear is immense*, all kinds of complaints and no responsible head is the rule. On the contract plan for light you pay for what you get only, and know what to provide for in the estimate for tax levy.

Q. 3.—If your city had the work to do over again, do you think they would do the same?—A. No.

Q. 4.—Has the municipal operation of your plant met all expectations and requirements?—A. No.

Topeka is another place where electric lights furnished by the city are cheaper than sunlight, and the city jubilant over their purchase. I quote from a letter written by a prominent official of the City of Topeka, which seems to prove that their millenium has not yet arrived. He says: "The agreement for all night lighting was $6 per light per month. We find that the cost of operating the plant of 184 lights for all night has been $11 per month. The agreement further provided that lights should be 2,000 candle-power; all the tests we have made do not show them to be over 500 candle-power. Our lights so far have been very unsatisfactory. My own opinion of the matter is that it would be much cheaper in the end for the city to have contracted with some of our electric light companies here to furnish the city with its lights at so much per light. We would then have known at least just what they would have cost. As it is, we have to take our medicine, which is liable to be a very expensive dose. It is a very expensive luxury, and there are so many expenses coming up that we cannot foresee; therefore, I say, when you take everything into consideration—interest on the investment, wear and tear on machinery, dynamos, &c. (the contractors are already building over ours, and they have not run two years yet)—consider well before contracting for a plant." Here is the opinion of an honest official, who has had experience with a city owning a plant.

Lewiston, Maine, is another brilliant example of municipal ownership. They have a plant of 100 arc lights, which cost the city $15,000. They burn, on an average, 24 nights per month on moonlight schedule, and the Mayor says the actual running expenses are $4,200 per year. Add interest on cost of plant, depreciation, 5 per cent., taxes, rent of water-power, which the city would have received from a private company; therefore it is costing the city for 100 arc lights, using water-power, $7,200, or $72 per lamp per year, while the local electric light company offered to furnish the same lights for $5,760, being $1,440 less than it costs the city to run their own lights; and still it has been advertised broadcast that the cost of arc lights in Lewiston was only 14 cents. per night.

I have secured reports from fifty municipal plants, embracing nearly all the cities and towns in the United States owning plants, and find that the cost of these has been $1,511,225; that they are using 3,725 lamps; 12 places running all night, and 38 until midnight or

on the moonlight schedule; that the average price paid for coal is $2.34 per ton; that the actual running expenses have been $251,194; that the interest on the cost of these plants is $90,691; depreciation at 5 per cent. $75,576; cost of replacing armatures actually burned out, $12,000; taxes city would have received from private corporations if they had furnished the lights, $15,715—making the total expense to these 50 cities of burning 3,725 lamps (two-thirds of them only until midnight) for one year $444,486, or an average cost of $119.24 per lamp per year. In the figures going to make up the cost of plants and the running expenses I have taken the statements and amounts as given by the city officials, but when we are told that the total amount paid for a complete plant of 68 arc lamps, with engines, boilers, dynamos, &c., was only $1,300, and informed that the total running expenses of a plant that cost $12,000 are only $1,100, and in the same communication the statement is made that they pay their engineer and linemen $125 per month, making annual bill for these men's wages of $1,500, we naturally long for the secret which enables them to settle this amount and pay for repairs, oil, coal and other expenses with an expenditure of only $1,100.

I have statistics from 365 electric light companies furnishing 35,100 arc lamps for street lighting, three-fifths burning their lights all night, and two-fifths burning until midnight, or on the moonlight schedule. The average cost of coal is $2.76 per ton. The average price charged per lamp for street lights is $118 per year. This is the price when furnished by electric light companies, who have assumed all the risks and liabilities incurred in the business, and who must furnish first-class lights. This is the cost with lights burning every night without a break, as the contract calls for, and necessitating a rebate if lights are out, which would reduce the price paid by the city.

Only one-third of the cities owning plants run them all night, while of street lights furnished by private companies three-fifths burn all night. Lamps all night and every night would burn 4,000 hours per lamp, while the moonlight schedule would only require about 2,100 hours per lamp. The cost to companies, of course, is much more for all night lights than it is until midnight, and had lights run by municipal plants been burned the same length of time as lamps furnished by private corporations the average cost would have been still more, as lights must have burned about twice as many hours.

It will be noticed that the average cost of coal used by municipal plants was $2.34 per ton, owing to the fact that the majority were located near the mines or places where coal was cheap, and the average as shown for electric light companies is $2.76 per ton, owing to the fact that coal was transported long distances, at high rates of freight. Even with this factor against them, it shows conclusively that private corporations are furnishing cities with lights for less money than they can themselves produce them while owning the plant. This, too, with the expense of operating city plants figured as given by the various cities, which their own report shows is incorrect, and less than actually paid.

It is well known that if a private corporation is furnishing municipal lights, when they are out for a short time or are not up to standard, a rebate has to be made, amounting in the aggregate to many thousands of dollars; but you will never see this item deducted when advocates of municipal control are quoting the cost of lights. Neither do they allow the fact of the city's liability for damages and accidents to be developed. If the municipality own the plant they assume these chances, and here is a feature of responsibility which in most States rests upon the individual as well as the city. The property of any citizen can be held for an execution against the town for injuries caused by a municipal plant, no matter if it amounts to thousands of dollars, and thus he might be deprived of his most valuable personal rights and liberties. If electric light companies furnish the lights, they must meet such claims and protect the city from loss, and the court records show that electric light companies have paid heavy damages on this account.

In the reports received from city officials regarding the cost and operation of their lights, one says: "No expenses charged to lighting account." Again: "Lights are not started for an hour after dark." Many say: "Whenever a thunderstorm approaches, lights are shut down and city left in darkness." Another says: "Have not had lights for past two weeks, owing to some trouble at station;" while many report wages of *employés* charged to water department, and others that no account of lighting expenses is kept. Here we have the basis upon which reports are made that the cost to cities owning plants is so much less than it is when private corporations furnish them, simply deceiving the taxpayers by charging part of the cost to other departments, while raising a hue-and-cry about the extortion of electric light companies.

No sane or fair-minded man will, with the corruption and fraud practised by politicians at the present day, attempt to prove that it is for the best interest of the taxpayer to place faith in the honest or conservative management of any enterprise which can be manipulated in the political arena for the advancement of the men in power. The histories of New York, Philadelphia and many other cities are samples of such methods and their purifying effects upon politics. Hypothesis and theory may do on paper, but actual results obtained by practical application and experience are the only reliable data upon which to base any statement relating to the cost of street lighting. In every case these have shown, where all the facts are given, that it has been for the best interest of the citizens and taxpayers to contract with an electric light company for lighting the streets of any city.

Many cities have found by actual experience, after spending a large amount of money, that this is a fact. The City of Greenville, S.C., has sold out its municipal electric lighting station, the purchasers agreeing to relieve the city of all pending liabilities in connection with the light plant. The city has agreed to pay $100 per year per lamp for not less than 40; the agreement to run for 15 years. Negotiations are pending in several other cities for a sale of their plants to the local or private electric lighting company, as they have found that it was impossible to produce the light, when managed by politicians with no interest in the business, as cheaply as could be done by a private corporation whose managers were financially interested in its success.

There is another feature of this business that it is well to consider. Under the authority and sanction of the Legislatures of the States, private capital amounting to millions of dollars has been invested in the enterprise of electric lighting. The benefit that municipalities have received from this capital is enormous, and it is a question whether the private capital thus locally invested under the sanction of the State can be jeopardised and endangered by the action of municipalities, who are subject to and under the control of the State In England this matter is fully settled, and no municipality can operate its own plant, if by so doing it will interfere with any local or private company authorised by Parliament.

Judging the future by the past, with the mighty strides that have been made in electrical inventions, two years from now the entire apparatus at present owned by municipalities may be consigned to the scrap pile, and necessitate a new outfit costing thousands of dollars. What is to be done in this case? Levy another tax or issue more bonds, and thus load the city with more debts. Electric light companies have already had this experience, and I can cite a case where the company paid $4,500 for their dynamos, and, after a little over two years, could only realise $300 from those same machines. Why is this? Simply that improved plans and apparatus have been discovered which reduces the cost of producing electricity, and unless companies can control these new patents they will be stranded in the race of invention.

Consider, then, for one moment the effect upon the

business world if to-day it were possible to blot out electricity and electric lights, with all their conveniences, comforts and luxuries; to stop the progress and development of this wonderful science, and shroud America in a gloom that could only be expressed by Byron when he "had a dream which was not all a dream," and

"The bright sun was extinguished,
And morn came and went—and came—and brought no day,
And all hearts were chilled into a selfish prayer for light.
The rivers, lakes and ocean all stood still,
And the clouds perished. Darkness had no need
Of aid from them—she was the Universe."

THE RELATIVE COST OF GAS AND ELECTRICITY IN COTTON MILLS.

WHEN it is attempted to draw comparisons between gas and electricity and their relative cost, it is not unusual to estimate the former by simply referring to the actual cost of the gas consumed as registered by the meter, whilst the cost of an electric light is obtained after every possible charge has been put down to its account. Such a result not infrequently places the electric light at a serious disadvantage from the economical point of view.

But an estimate of this character is far too one-sided to give a true statement of the case. Those who are interested in the electrical industry do not object in the least to have the electric light properly debited with all the incidental and necessary items, but they do naturally object that, on the gas side, all the incidental items, save that of actual consumption, should be omitted. Neither is it fair altogether to omit from these calculations the relative benefits, or otherwise, derived from the use of the two illuminants.

As we have remarked, an electric light installation is debited with all its charges to the capital account, and in its maintenance not only is the depreciation of the plant considered, but every item due to repairs, wages, &c., is fully considered and provided for.

On the gas side, however, no such items are usually taken into account; but, dealing with the gas question in a large mill or manufactory, there are a number of expenses necessarily entailed, which should certainly be taken into account when a perfectly true and reliable comparison is desired. For instance, the installation of a gas plant of 1,000 or more lights into a large mill entails the expenditure of a considerable amount of capital, although it is known that a gas plant can be put in at the present time for a very small sum. There are, however, many mills where the capital expended upon the gas installation has cost 20s. per light, whilst at the present time they can be installed for as low as 5s. or 6s. per jet. Still, this requires some capital, and, necessarily, should be subject to some charge for depreciation. The lighting up of a large mill, and the extinguishing of these lights requires a considerable amount of labour and time. The value of wages taken up per annum in this alone is a serious item, but it does not count. It will be found that where there are a large number of lights in use there is almost always a "gasman" employed in looking after the fittings, and keeping everything in proper repair; but his wages are not counted, nor are the various items which usually come under the head of repairs, for it is impossible to conceive that gas-pipes and fixtures are never out of order.

When the relative charges are properly considered, a more reliable estimate can therefore be obtained; but there are circumstances which prevent such a comparison from being made; this is owing to the fact that it is very rare for the cost of the maintenance of an electric light installation to be kept. We are aware, however, of several cases where this has been done, and we have had the following statement presented to us for publication, which gives the information in a comparative form, prepared by the proprietors of some very large mills in the neighbourhood of Manchester. These results give the relative cost of gas and electricity for a period of six years, taken from the actual working experience of one of the company's mills at Mossegate, near Bolton. The statement is given exactly as handed to us.

HORROCKS, CREWDSON & CO., LIMITED, BOLTON.

Gas v. Electricity at Mossegate.

SIX YEARS TO DECEMBER 31st, 1889.

	£	s.	d.
826 gas lights, cost for piping, meter, &c.	215	2	2
Depreciation at 5 per cent. per annum—6 years = £73 12s. 11d.; or, per annum	12	5	6
Average gas account, per annum	217	11	3
826/	229	16	9
Cost of gas per light per annum	0	5	6¼
Electric installation (263 lamps) cost, including gearing, belting, &c.	410	17	9
Depreciation at 7½ per cent. per annum, 6 years ...	153	10	1
Renewal of lamps, repairs, &c.	101	11	4
Power estimated at 30 I.H.P. at £5 = £150. Depreciation on £150 for 6 years, at 5 per cent. per annum	39	14	4
Coal at 3·7 lb. per I.H.P. per hour (275 hours per ann.), for six years at 6s. per ton	22	2	0
6/316	17	9	
Cost per annum 263/	52	16	3½
Cost per lamp per annum	0	4	0½

Cost per light per annum—Gas, 5s. 6¼d. — Electricity, 4s. 0½d.

Gas costs 38·34 per cent. more per light, and (as one electric light displaces two gas lights in weaving shed), gas costs 176·68 per cent more per loom.

It will be observed that, in the foregoing statement, the gas account is simply debited with the average gas consumption and a depreciation charge of 5 per cent. upon the original cost, nothing being allowed for repairs and such other charges as we have previously mentioned.

The account for the electric installation of 263 lights includes dynamos and everything that is necessary to a complete plant. The work in this case was satisfactorily done by the Manchester Edison-Swan Company, Limited, and it is gratifying to notice here that, throughout the six years, the working has been of a satisfactory character. The charge for depreciation is 7½ per cent., or one-half more than in the case of gas. The power of the steam engine is estimated at 30 I.H.P., that being the proportion of the main engine of the mill, utilised for the purpose of driving the dynamo. Tests subsequently made showed that the actual I.H.P. utilised was only 27 H.P., and at this figure the coal consumption has been calculated. The item for repairs, &c., includes the cost of oil and sundries, besides lamp renewals. It will therefore be seen that full charges have been debited to the electric light account. It may probably be remarked that no charge has been made on account of wages, but as the engineer in charge of the engines has done this small amount of work as part of his ordinary duty, no charge has been made, for no extra expense has been incurred.

Under these circumstances, the electric light shows a very distinct economy over gas, and it must be acknowledged that, in the case of a weaving shed, the result is very remarkable.

The present is a case where the mill engines have had their surplus power utilised in favour of the electric light installation, a case by no means unusual, and one which would undoubtedly be more frequently adopted if mill-owners were more alive to this fact. In a very large number of instances, the power required for the electric light has been in excess of that which could possibly be obtained from the mill engine, and an independent engine has been provided; and in

other instances it has been considered advisable to have the power for the electric light quite independent. In these circumstances, again, an economy in the use of the electric light has been proved, and in a succeeding number we propose to give some details of the cost of working, with the additional charge of independent engines.

RESEARCHES ON THE ACTION OF ELECTRICITY UPON CERTAIN GASES.

THE researches of Berthelot into the action of electric discharges upon gaseous bodies have come to be regarded as classical by physicists. His results have been accumulated by a patient investigation which it would well become our younger scientists to emulate. Unfortunately, for the cause of true science, the tendency of the times is, in many matters of great importance, becoming characterised by a certain degree of hurry which, if persisted in, will be fatal to many a career, and, what is worse, to many a question of scientific interest and practical usefulness.

Long ago Berthelot began the systematic study of the action of electricity upon gases and vapours. One of these was carbonic oxide [CO]. This gas has been known for more than a hundred years, having first been obtained by Lasonne in 1776. Priestly was familiar with it but by some strange delusion he supposed that it was the gas which we now know as hydrogen. Carbonic oxide can be made in many ways, most of which are strictly chemical in character. Amongst other methods that of Buff and Hofmann (vide *Liebig's Annalen der Chemie*, vol. 113, p. 140) is of interest to electricians. They produced it by passing a series of electric sparks through carbonic acid gas, CO_2.

Carbonic oxide when pure is a slightly odorous gas without taste or colour, it will burn and it is extremely poisonous.

There are few compound gases but are influenced by the decomposing action of the electric spark. Carbonic oxide is a typical instance of this; electric sparks, according to Berthelot, cause a partial decomposition to carbonic anhydride (CO_2), and if the CO_2 be removed by absorption the change proceeds (vide *Annales de Chimie et de Physique*, Series 5, Vol. XXX. p. 547).

Dixon, writing in the *Journal of the Chemical Society*, Vol. XLIX., p. 103, states that sparks from a Leyden jar will decompose carbonic oxide, but that only about half per cent. of the total gas is decomposed by this form of electricity. This scientist has also investigated the action of electricity upon a mixture of carbonic oxide and oxygen. He finds that such a mixture is burnt to carbonic anhydride by the application of an electric spark, just as it is by the application of flame. If, however, both gases are perfectly dry, no chemical change occurs when the spark is passed. A mere trace of steam present is sufficient to render the mixture explosive. If only a very small quantity of steam is present, the change takes place very slowly under the action of electricity; but when the amount of steam is increased, the rapidity of the explosion is increased proportionately. It appears that the steam acts as a *carrier* of oxygen to the carbonic oxide: it is probably reduced to hydrogen, and this is then oxidised again. Dixon's work may be read in the *Transactions of the Royal Society* for 1884, p. 617. Buff and Hofmann thought that a dry mixture of carbonic oxide and oxygen would not explode, but L. Meyer's experiments seem to prove that such a mixture *can* be exploded if the operator will use a sufficiently strong spark; the temperature is thus made very high. Other conditions, however, appear to be necessary. The gases must be under considerable pressure: the more dilute the gaseous mixture is, the more difficult it is to explode (vide *Berichte der Deutschen Chemischen Gesellschaft*, Vol. XIX., p. 1,099).

When sparks from an induction coil are passed into a mixture of carbonic oxide and steam, the constituents are dissociated and recombined, the result being carbonic anhydride, a little formic acid, and sometimes free carbon. This observation is also due to Dixon.

It has, further, been shown that if hydrogen and oxygen, the constituents of steam, be added to carbonic oxide, the mixture will explode on the application of an electric spark, and carbonic anhydride and water will be formed. The ratio of these products to each other depends, curiously enough, upon the shape of the vessel, and on the pressure up to a certain limit, which may be called the "critical pressure"; above this limit the ratio is independent of the shape of the vessel. It would be interesting to trace the causes of this very curious result.

Returning now to the researches of Berthelot. In the *Bulletin de la Société Chimique de Paris*, series (2), Vol. XXI., p. 102, is a paper in which he asserts that carbonic oxide is decomposed by the silent electric discharge being converted into carbonic anhydride by a brown substance to which he assigned the formula $C_5 O_4$. Brodie, however, argued at the time that the composition was best expressed by the formula $C_4 O_3$.

Now, according to the more recent researches of P. Schutzenberger, the composition of the dark brown product is variable, and, further, the condensation of the carbonic oxide ceases as soon as the gas contains 10 per cent. of carbonic anhydride.

Schutzenberger's experiments, which have just been described before the French Academy of Science, were made with a simple discharge tube of the Wilde-Berthelot form, the open end dipping under mercury, whilst the armatures were acidified water.

Under these conditions the rate of condensation varied considerably, but was practically constant for the same tube used in the same way. The solid product had the composition:—

Carbon	45·6
Hydrogen	0·6
Oxygen	53·8
	100·0

When the armatures of acidified water were replaced by mercury condensation was much slower, and the black product had the composition:—

Carbon	46·4
Hydrogen	0·9
Oxygen	52·7
	100·0

If the armatures were surrounded by jackets containing dry air, and every precaution taken to exclude moisture, very little condensation took place, even when the discharge was continued for 48 hours. It follows that the presence of small quantities of water is essential to the formation of the black product, and Schutzenberger considers that the electric discharge carries oxygen and water through the glass, and that there is also some evidence of a transport of matter in the opposite direction, since the total quantity of carbon in the condensed product and the carbonic anhydride was less than that in the carbonic oxide which disappeared.

Berthelot, in a still more recent contribution to the proceedings of the same learned body, states that condensation of carbonic oxide under the influence of the silent electric discharge takes place even when the gas is separated from water by the walls of two tubes, and by an intervening air space, the gas and the apparatus having been very carefully dried.

The condensation and the composition of the residual gas show that the solid matter has the composition $C_4 O_3$, which confirms his earlier experiments described in the *Bulletin de la Société Chimique de Paris*, Series 2, Vol. XXI., p. 102, and in the *Annales de Chimie et de Physique*, Series 5, Vol. XVII., p. 142.

Berthelot is also at variance with Schutzenburger with regard to the question of the electric discharge causing the passage of water through the glass. He

considers that there is no scientific evidence of it, and that Schutzenburger is only hazarding an opinion.

Schutzenburger, however, has rejoined that in some experiments described in the *Comptes Rendus*, Vol. CX., p. 681, evidence is there given which fully bears out his views. There is, however, reason to believe that the presence of the moisture is to be accounted for by the extreme difficulty of perfectly drying either glass or mercury.

But there is room for independent effort on other lines of research, for evidently the whole truth concerning the action of the silent electric discharge upon carbonic oxide has not yet been revealed.

Quite recently the condensation of benzene and acetylene, under the influence of the silent discharge, has been placed under investigation by Schutzenburger.

Benzene, $C_6 H_6$, is a hydrocarbon which has not yet been prepared by electrical methods. In its normal state, at ordinary temperature and pressure, it is a colourless, mobile, strongly refracting liquid, which will burn with a luminous flame. It is usually prepared from coal tar by distillation, fractionation and rectification, according to methods which have been developed by Faraday, Hofmann and Mansfield.

Although it has hitherto been found impossible to prepare benzene by the action of electricity, it is susceptible to change under its influence. If induction sparks be passed through liquid benzene, a gaseous mixture is formed which contains 42 per cent. of acetylene and 57 per cent. of hydrogen. This fact was observed by Destrem (vide *Bulletin de la Société Chimique de Paris*, Series 2, Vol. XLII., p. 267).

Acetylene, on the other hand, can be produced by electricity acting upon the elements carbon and hydrogen, of which it is constituted. Acetylene, called, also, ethine and ethinene, is an ill-smelling gas which occurs normally in coal gas. It is generated by the incomplete combustion of hydrocarbons. Its characteristic odour may be observed when a Bunsen-lamp flame "strikes down" and burns within the chimney.

Berthelot prepared acetylene synthetically by passing hydrogen over charcoal, heated to whiteness, in the electric arc (vide *Comptes Rendus*, Vol. LIV., p. 640).

Dewar obtained the same gas when hydrogen was passed through holes drilled through the centre of carbon points at the same time as these points were discharging powerful sparks (vide *Proceedings of the Royal Society*, Vol. XXIX., 1880).

Acetylene can also be made by another method, devised by Berthelot, which consists in exposing marsh, or coal gas, to the sparks of a powerful induction coil (*vide Comptes Rendus*, LIV., p. 515). The vapours of many organic compounds, *e.g.*, alcohol, ether, acetene, ethylene, benzene, &c., likewise yield acetylene, when induction sparks are passed through them. This was discovered by De Wilde. Berthelot has also obtained it by the electrolysis of a solution of potassium aconitate or succinate. To prepare acetylene in large quantity, however, it would be best to resort to purely chemical methods.

The study of the action of the silent discharge upon acetylene and benzene was conducted by Schutzenberger as follows:

The tubes containing the substances to be experimented upon were hermetically sealed, and thus the contents were cut off from any possible absorption of moisture from the air. It was found that after the discharge had been continued for five or six hours, the inner tube was very liable to break, a result due to the fact that the prolonged action of the discharge makes the glass brittle. If the tubes are quite vacuous fracture takes place after a very few minutes.

Under the influence of the silent discharge, benzene vapour gradually condenses to a pale yellow, resinous, transparent solid, the liquid benzene gradually disappearing. The product contains

Carbon	85·9 to 91·63	per cent.	
Hydrogen	7·1 „ 7·81	„	„
Oxygen	0·7 „ 7·0	„	„

The composition of the product depends upon whether it is formed on the inner tube or the outer tube.

	C.	H.	O.
Inner tube ...	90·54 ...	7·30 ...	2·10
Outer „ ...	87·14 ...	7·48 ...	5·38

The results agree with those obtained with acetylene, which gives a product containing 2 to 5 per cent. of oxygen.

Schutzenberger also adduces what he considers further evidences of his theory, that the action of the silent electric discharge affects the glass so that it becomes permeable to water.

It is only by carefully studying the chemical and physical properties of substances that we can form any true conception of the nature of these bodies; possibly the same principle may hold with regard to the various phases of electricity, and hence by studying closely their chemical effects upon well-known bodies as well as their own purely physical characteristics, we may in time arrive at a more lucid conception of these also.

THE ELECTRO-MAGNET.*

By Prof. SILVANUS P. THOMPSON, D.Sc., B.A., M.I.E.E.

LECTURE I.

Historical Introduction—Generalities about Forms and Uses of Electro-magnets—The Magnetic Properties of Iron.

INTRODUCTORY.

AMONGST the great inventions which have originated in the lecture room in which we are met are two of special interest to electricians—the application of gutta-percha to the purpose of submarine telegraph cables, and the electro-magnet. This latter invention was first publicly described, from the very platform on which I stand, on May 23rd, 1825, by William Sturgeon, whose paper is to be found in the forty-third volume of the "Transactions of the Society of Arts." For this invention we may rightfully claim the very highest place. Electrical engineering, the latest and most vigorous offshoot of applied science, embraces many branches. The dynamo for generating electric currents, the motor for transforming their energy back into work, the arc lamp, the electric bell, the telephone, the recent electro-magnetic machinery for coal mining, for the separation of ore, and many other electro-mechanical contrivances, come within the purview of the electrical engineer. In every one of these, and in many more of the useful applications of electricity, the central organ is an electro-magnet. By means of this simple and familiar contrivance—an iron core surrounded by a copper wire coil—mechanical actions are produced at will, at a distance, under control, by the agency of electric currents. These mechanical actions are known to vary with the mass, form, and quality of the iron core, the quantity and disposition of the copper wire wound upon it, the quantity of the electric current circulating around it, the form, quality, and distance of the iron armature upon which it acts. But the laws which govern the mechanical action in relation to these various matters are by no means well known, and, indeed, several of them have long been a matter of dispute. Gradually, however, that which has been vague and indeterminate becomes clear and precise. The laws of the steady circulation of electric currents, at one time altogether obscure, were cleared up by the discovery of the famous law of Ohm. Their extension to the case of rapidly interrupted currents, such as are used in telegraphic working, was discovered by Helmholtz; whilst to Maxwell is due their further extension to alternating, or, as they are sometimes called, undulatory currents. All this was purely electric work. But the law of the electro-magnet was still undiscovered; the magnetic part of the problem was still buried in obscurity. The only exact reasoning about magnetism dealt with problems of another kind; it was couched in language of a misleading character; for the practical problems connected with the electro-magnet it was worse than useless. The doctrine of two magnetic fluids distributed over the end surfaces of magnets, which under the sanction of the great names of Coulomb, of Poisson, and of Laplace, had unfortunately become recognised as an accepted part of science, along with the law of inverse squares. How greatly the progress of electro-magnetic science has been impeded and retarded by the weight of these great names it is impossible now to gauge. We now know that for all purposes, save only those whose value lies in the domain of abstract mathematics, the doctrine of the two magnetic fluids is false and misleading. We know that magnetism, so far from residing on the end or surface of the magnet, is a pro-

*Cantor Lecture. Delivered before the Society of Art January 20th, 1890.

perty resident throughout the mass; that the internal not the external magnetisation is the important fact to be considered; that the so-called free magnetism on the surface is, as it were, an accidental phenomenon; that the magnet is really most highly magnetised at those parts where there is least surface magnetisation; finally, that the doctrine of surface distribution of fluids is absolutely incompetent to afford a basis of calculation such as is required by the electrical engineer. He requires rules to enable him not only to predict the lifting power of a given electro-magnet, but also to guide him in designing and constructing electro-magnets of special forms suitable for the various cases that arise in his practice. He wants in one place a strong electro-magnet to hold on to its armature like a limpet to its native rock; in another case he desires a magnet having a very long range of attraction, and wants a rule to guide him to the best design; in another he wants a special form having the most rapid action attainable; in yet another he must sacrifice everything else to attain maximum action with minimum weight. Toward the solution of such practical problems as these the old theory of magnetism offered not the slightest aid. Its array of mathematical symbols was a mockery. It was as though an engineer asking for rules to enable him to design the cylinder and piston of an engine were confronted with receipts how to estimate the cost of painting it.

Gradually, however, new light dawned. It became customary, in spite of the mathematicians, to regard the magnetism of a magnet as something that traverses or circulates round a definite path, flowing more freely through such substances as iron, than through other relatively non-magnetic materials. Analogies between the flow of electricity in an electrically-conducting circuit, and the passage of magnetic lines of force through circuits possessing magnetic conductivity, forced themselves upon the minds of experimenters, and compelled a mode of thought quite other than the previously accepted. So far back as 1821, Cumming* experimented on magnetic conductivity. The idea of a magnetic circuit was more or less familiar to Ritchie,† Sturgeon,‡ Dove,§ Dub,‖ and De La Rive,¶ the last-named of whom explicitly uses the phrase, "a closed magnetic circuit." Joule** found the maximum power of an electro-magnet to be proportional to "the least sectional area of the entire magnetic circuit," and he considered the resistance to induction as proportional to the length of the magnetic circuit. Indeed, there are to be found scattered in Joule's writings on the subject of magnetism, some five or six sentences, which, if collected together, constitute a full statement of the whole matter. Faraday,†† considered that he had proved that each demagnetic line of force constitutes a closed curve; that the path of these closed curves depended on the magnetic conductivity of the masses disposed in proximity; that the lines of magnetic force were strictly analogous to the lines of electric flow in an electric circuit. He spoke of a magnet surrounded by air being like unto a voltaic battery immersed in water or other electrolyte. He even saw the existence of a power, analogous to that of electromotive force in electric circuits, though the name, "magnetomotive force," is of more recent origin. The notion of magnetic conductivity is to be found in Maxwell's great treatise (vol. ii., p. 51), but is only briefly mentioned. Rowland,‡‡ in 1873, expressly adopted the reasoning and language of Faraday's method in the working out of some new results on magnetic permeability, and pointed out that the flow of magnetic lines of force through a bar could be subjected to exact calculation; the elementary law, he says, "is similar to the law of Ohm." According to Rowland, the "magnetising force of helix" was to be divided by the "resistance to the lines of force," a calculation for magnetic circuits which every electrician will recognise as precisely as Ohm's law for electric circuits. He applied the calculations to determine the permeability of certain specimens of iron, steel, and nickel. In 1882,§§ and again in 1883, Mr. R. H. M. Bosanquet ‖‖ brought out at greater length a similar argument, employing the extremely apt term, "Magnetomotive Force," to connote the force tending to drive the magnetic lines of induction through the "magnetic resistance," or, as it will be frequently called in these lectures, the magnetic "reluctance" of the circuit. In these papers the calculations are reduced to a system, and deal not only with the specific properties of iron, but with problems arising out of the shape of the iron. Bosanquet shows how to calculate the several resistances (or reluctances) of the separate parts of the circuit, and then add them together to obtain the total resistance (or reluctance) of the magnetic circuit.

Prior to this, however, the principle of the magnetic circuit had been seized upon by Lord Elphinstone and Mr. Vincent, who proposed to apply it in the construction of the dynamo-electric machines. On two occasions* they communicated to the Royal Society the results of experiments to show that the same exciting current would evoke a larger amount of magnetism in a given iron structure, if that iron structure formed a closed magnetic circuit, than if it were otherwise disposed.

In recent years the notion of the magnetic circuit has been vigorously taken up by the designers of dynamo machines, who, indeed, base the calculation of their designs upon this all-important principle. Having this, they need no laws of inverse squares of distances, no magnetic moments, none of the elaborate expressions for surface distribution of magnetism, none of the ancient paraphernalia of the last century. The simple law of the magnetic circuit, and a knowledge of the properties of iron, are practically all they need. About four years ago, much was done by Mr. Gisbert Kapp† and by Drs. J. and E. Hopkinson‡ in the application of these considerations to the design of dynamo machines, which previously had been a matter of empirical practice. To this end the formulæ of Prof. Forbes§ for calculating magnetic leakage, and the researches of Profs. Ayrton and Perry‖ on magnetic shunts, contributed a not unimportant share. As the result of the advances made at that time, the subject of dynamo design was reduced to an exact science.

It is the aim and object of the present course or lectures to show how the same considerations which have been applied with such great success to the subject of the design of dynamo electric machines may be applied to the study of the electro-magnet. The theory and practice of the design and construction of electro-magnets will thus be placed, once for all, upon a rational basis. Definite rules will be laid down for the guidance of the constructor, directing him as to the proper dimensions and form of iron to be chosen, and as to the proper size and amount of copper wire to be wound upon it in order to produce any desired result.

First, however, a historical account of the invention will be given, followed by a number of general considerations respecting the uses and forms of electro-magnets. These will be followed by a discussion of the magnetic properties of iron and steel and other materials; some account being added of the methods used for determining the magnetic permeability of various brands of iron at different degrees of saturation. Tabular information is given as to the results found by different observers. In connection with the magnetic properties of iron the phenomenon of magnetic hysteresis is also described and discussed. The principle of the magnetic circuit is then discussed with numerical examples, and a number of experimental data respecting the performance of electro-magnets are adduced, in particular those bearing upon the tractive power of electro-magnets. The law of traction between an electro-magnet and its armature is then laid down, followed by the rules for pre-determining the iron cores and copper coils required to give any prescribed tractive force.

Then comes the extension of the calculation of the magnetic circuit to those cases where there is an air gap between the poles of the magnet and the armature; and where, in consequence, there is leakage of the magnetic lines from pole to pole. The rules for calculating the winding of the copper coils are stated, and the limiting relation between the magnetising power of the coil and the heating effect of the current in it is explained. After this comes a detailed discussion of the special varieties of form that must be given to electro-magnets in order to adapt them to special services. Those which are designed for maximum traction, for quickest action, for longest range, for greatest economy when used in continuous daily service, for working in series with constant current, for use in parallel at constant pressure, and those for use with alternate currents, are separately considered.

Lastly, some account is given of the various forms of electro-magnet mechanism which have arisen in connection with the invention of the electro-magnet. The plunger and coil is specially considered as constituting a species of electro-magnet adapted for a long range of motion. Modes of mechanically securing long range for electro-magnets, and of equalising their pull over the range of motion of the armature, are also described. The analogies between sundry electro-mechanical movements, and the corresponding pieces of ordinary mechanism are traced out. The course is concluded by a consideration of the various modes of preventing or minimising the sparks which occur in the circuits in which electro-magnets are used.

HISTORICAL SKETCH.

The effect which an electric current, flowing in a wire, can exercise upon a neighbouring compass needle was discovered by

* "Camb. Phil, Trans.," April 2nd, 1821.
† "Phil. Mag.," series iii., vol. iii., p. 122.
‡ "Ann. of Electr.," xii., p. 217.
§ "Pogg. Ann.," xxix., p. 462, 1833. See also "Pogg. Ann.," xliii., p. 517, 1838.
‖ "Dub. Elektromagnetismus" (ed. 1861), p. 401; and "Pogg. Ann.," xc., p. 440, 1853.
¶ De La Rive. "Treatise on Electricity" (Walker's translation), vol. i., p. 292.
** "Ann. of Electr.," iv., 59, 1839; v., 195, 1841; and "Scientific Papers," pp. 8, 34, 35, 36.
†† "Experimental Researches," vol. iii., art. 3117, 3228, 3230, 3260, 3271, 3276, 3294, and 3361.
‡‡ "Phil. Mag.," series iv., vol. xlvi., August, 1873, "On Magnetic Permeability and the Maximum of Magnetism of Iron, Steel, and Nickel."
§§ "Proc. Royal Soc., xxxiv., p. 445, December, 1882.
‖‖ "Phil. Mag.," series v., vol. xv., p. 205, March, 1883. "On Magneto-Motive Force." Also *ib.*, vol. xix., February, 1885, and "Proc. Roy. Soc." No. 223, 1883. See also *Electrician*, xiv., p. 291, February 14th, 1885.

* "Proc. Roy. Soc.," xxix., p. 292, 1879, and xxx., p. 287, 1880. See ELECTRICAL REVIEW, viii., p. 134, 1880.
† The *Electrician*, vols. xiv., xv., and xvi., 1885-6; also "Proc. Inst. Civil Engineers," lxxxiii., 1885-6; and "Journ. Soc. Telegr. Engineers," xv., 524, 1886.
‡ "Phil. Trans.," 1886, pt. i., p. 331; and *The Electrician* xviii., pp. 39, 63, 86, 1886.
§ "Journ. Soc. Telegr. Engineers," xv., 555, 1886.
‖ "Journ. Soc. Telegr. Engineers," xv., 530, 1886.

Oersted in 1820.* This first announcement of the possession of magnetic properties by an electric current was followed speedily by the researches of Ampère,† Arago,‡ Davy,§ and by the devices of several other experimenters, including De la Rives‖ floating battery and coil, Schweigger's ¶ multiplier, Cumming's** galvanometer, Faraday's†† apparatus for rotation of a permanent magnet, Marsh's‡‡ vibrating pendulum, and Barlow's§§ rotating star-wheel. But it was not until 1825 that the electro-magnet was invented. Davy had, indeed, in 1821, surrounded with temporary coils of wire the steel needles upon which he was experimenting, and had shown that the flow of electricity around the coil could confer magnetic power upon the steel needles. But from this experiment it was a grand step forward to the discovery that a core of soft iron, surrounded by its own appropriate coil of copper, could be made to act not only as a powerful magnet, but as a magnet whose power could be turned on or off at will, could be augmented to any desired degree, and could be set into action and controlled from a practically unlimited distance.

The electro-magnet, in the form which can first claim recognition for these qualities, was devised by William Sturgeon,‖‖ and is described by him in the paper which he contributed to the proceedings of the Society of Arts in 1825, accompanying a set of improved apparatus for electro-magnetic experiments.¶¶ The

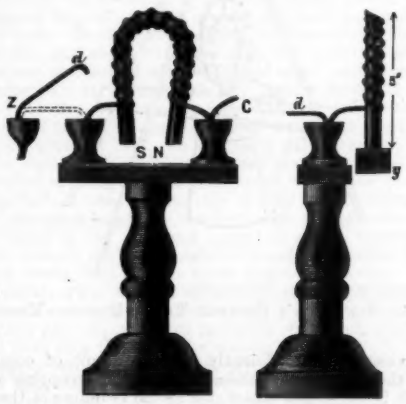


FIG. 1. FIG. 2.

STURGEON'S FIRST ELECTRO-MAGNET.

Society of Arts rewarded Sturgeon's labours by awarding him the silver medal of the Society and a premium of thirty guineas. Amongst this set of apparatus are two electro-magnets, one of horseshoe shape (figs. 1 and 2) and one a straight bar (fig. 3). It will be seen that the former figures represent an electro-magnet consisting of a bent iron rod about one foot long and half inch in diameter, varnished over and then coiled with a single left-handed spiral of stout uncovered copper wire of 18 turns. This coil was found appropriate to the particular battery which Sturgeon preferred, namely, a single cell containing a spirally enrolled pair of zinc and copper plates of large area (about 130 square inches) immersed in acid; which cell, having small internal resistance would yield a large quantity of current when connected to a circuit of small resistance. The ends of the copper wire were brought out sideways and bent down so as to dip into two deep connecting cups, marked z and c, fixed upon a wooden stand. These cups, which were of wood, served as supports to hold up the electro-magnet, and, having mercury in them, served also to make good electrical connection. In fig. 2 the magnet is seen sideways, supporting a bar of iron, y. The circuit was completed to the battery through a connecting wire, *d*, which could be lifted out of the cup, z, so breaking circuit when desired, and allowing the weight to drop. Sturgeon added in his explanatory remarks that the poles, N and S, of the magnet will be reversed if you wrap the copper wire about the rod as a right-handed screw, instead of a left-handed one, or, more simply, by reversing the connections with the battery, by causing the wire that dips into the z cup to dip into the c cup, and *vice versa*. This electro-magnet was capable of supporting 9 lbs. when thus excited.

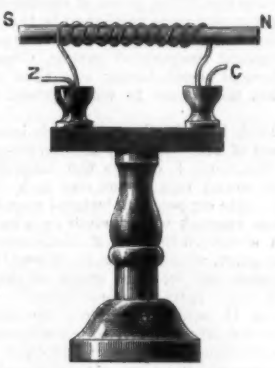


FIG. 3.—STURGEON'S STRAIGHT BAR ELECTRO-MAGNET.

Fig. 3 shows another arrangement to fit on the same stand. This arrangement communicates magnetism to hardened steel bars, as soon as they are put in, and renders soft iron within it magnetic during the time of action; it only differs from figs. 1 and 2 in being straight, and thereby allows the steel or iron bar to slide in and out.

For this piece of apparatus and other adjuncts accompanying it, all of which are described in the Society's "Transactions" for 1825, Sturgeon, as already stated, was awarded the Society's silver medal and a premium of 30 guineas. The apparatus was deposited in the museum of the Society, which therefore might be supposed to be the proud possessor of the first electro-magnet ever constructed. Alas for the vanity of human affairs, the Society's museum of apparatus has long been dispersed, this priceless relic having been either made over to the now defunct Patent Office Museum, or otherwise lost sight of.

Sturgeon's first electro-magnet, the core of which, weighing about 7 oz., was able to sustain a load of 9 lbs., or about 20 times its own weight. At the time it was considered a truly remarkable performance. Its single layer of stout copper wire was well adapted to the battery employed, a single cell of Sturgeon's own particular construction, having a surface of 130 square inches, and therefore of small internal resistance. Subsequently, in the hands of Joule, the same electro-magnet sustained a load of 50 lbs., or about 114 times its own weight. Writing in 1832 about his apparatus of 1825, Sturgeon used the following magniloquent language:—

"When first I showed that the magnetic energies of a galvanic conducting wire are more conspicuously exhibited by exercising them on soft iron than on hard steel, my experiments were limited to small masses—generally to a few inches of rod iron of about half an inch in diameter. Some of those pieces were employed while straight, and others were bent into the form of a horse-shoe magnet, each piece being encompassed by a spiral conductor of copper wire. The magnetic energies developed by those simple arrangements are of a very distinguished and exalted character, as is conspicuously manifested by the suspension of a considerable weight at the poles during the period of excitation by the electric influence.

"An unparalleled transiliency of magnetic action is also displayed in soft iron, by an instantaneous transition from a state of total inactivity to that of vigorous polarity, and also by a simultaneous reciprocity of polarity in the extremities of the bar—versatilities in this branch of physics for the display of which soft iron is pre-eminently qualified, and which, by the agency of electricity, become demonstrable with the celerity of thought, and

* See Thomson's "Annals of Philosophy," Oct., 1820.
† "Ann. de Chim. et de Physique," xv., 59 and 170, 1820.
‡ *Ib.*, xv., 93, 1820.
§ "Phil. Trans.," 1821.
‖ "Bibliothèque Universelle," March, 1821.
¶ *Ib.*
** "Camb. Phil. Trans.," 1821.
†† "Quarterly Journal of Science," Sept., 1821.
‡‡ Barlow's "Magnetic Attractions," second edition, 1823.
§§ *Ib.*
‖‖ William Sturgeon, the inventor of the electro-magnet, was born at Whittington, in Lancashire, in 1783. Apprenticed as a boy to the trade of a shoemaker, at the age of nineteen he joined the Westmoreland Militia, and two years later enlisted into the Royal Artillery, thus gaining the chance of learning something of science, and having leisure in which to pursue his absorbing passion for chemical and physical experiments. He was forty-two years of age when he made his great, though at the time unrecognised, invention. At the date of his researches in electro-magnetism, he was resident at 8, Artillery Place, Woolwich, at which place he was the associate of Marsh, and was intimate with Barlow, Christie, and Gregory, who interested themselves in his work. In 1835 he presented a paper to the Royal Society, containing descriptions, *inter alia*, of a magneto-electric machine with longitudinally-wound armature, and with a commutator consisting of half-disks of metal. For some reason this paper was not admitted to the "Philosophical Transactions;" he afterwards printed it in full, without alteration, in his volume of Scientific Researches, published by subscription in 1850. From 1836 to 1843 he conducted the "Annals of Electricity." He had now removed to Manchester, where he lectured on electricity at the Royal Victoria Gallery. He died at Prestwich, near Manchester, in 1850. There is a tablet to his memory in the church at Kirkby Lonsdale, from which town the village of Whittington is distant about two miles. A portrait of Sturgeon in oils, and said to be an excellent likeness, is believed still to be in existence; but all inquiries as to its whereabouts have proved unavailing. At the present moment, so far as I am aware, the scientific world is absolutely without a portrait of the inventor of the electro-magnet.
¶¶ "Trans. Society of Arts," 1825, xliii., p. 38.

illustrated by experiments the most splendid in magnetics. It is, moreover, abundantly manifested by ample experiments that galvanic electricity exercises a superlative degree of excitation on the latent magnetism of soft iron, and calls for its recondite powers with astonishing promptitude, to an intensity of action far surpassing anything which can be accomplished by any known application of the most vigorous permanent magnet, or by any other mode of experimenting hitherto discovered. It has been observed, however, by experimenting on different pieces selected from various sources, that, notwithstanding the greatest care be observed in preparing them of a uniform figure and dimensions, there appears a considerable difference in the susceptibility which they individually possess of developing the magnet powers, much of which depends upon the manner of treatment at the forge, as well as upon the natural character of the iron itself.*

"The superlative intensity of electro-magnets, and the facility and promptitude with which their energies can be brought into play, are qualifications admirably adapted for their introduction into a variety of arrangements in which powerful magnets so essentially operate, and perform a distinguished part in the production of electro-magnet rotations; whilst the versatilities of polarity of which they are susceptible are eminently calculated to give a pleasing diversity in the exhibition of that highly interesting class of phenomena, and lead to the production of others inimitable by any other means."†

Sturgeon's further work during the next three years is best described in his own words:—

"It does not appear that any very extensive experiments were attempted to improve the lifting power of electro-magnets, from the time that my experiments were published in the 'Transactions of the Society of Arts, &c.,' for 1825, till the latter part of 1828. Mr. Watkins, philosophical instrument maker, Charing Cross, had, however, made them of much larger size than any which I had employed, but I am not aware to what extent he pursued the experiment.

"In the year 1828, Prof. Moll, of Utrecht, being on a visit to London, purchased of Mr. Watkins an electro-magnet weighing about 5 lbs.—at that time I believe the largest which had been made. It was of round iron, about one inch in diameter, and furnished with a single copper wire twisted round it eighty-three times. When this magnet was excited by a large galvanic surface, it supported about 75 lbs. Prof. Moll afterwards prepared another electro-magnet, which, when bent, was 12½ inches high, 2½ inches in diameter, and weighed about 26 lbs.; prepared like the former with a single spiral conducting wire. With an acting galvanic surface of 11 square feet, this magnet would support 154 lbs., but would not lift an anvil which weighed 200 lbs.

"The largest electro-magnet which I have yet (1832) exhibited in my lectures weighs about 16 lbs. It is formed of a small bar of soft iron, 1½ inch across each side; the cross piece, which joins the poles, is from the same rod of iron, and about 3¾ inches long. Twenty separate strands of copper wire, each strand about 50 feet in length, are coiled round the iron, one above another, from pole to pole, and separated from each other by intervening cases of silk. The first coil is only the thickness of one ply of silk from the iron; the twentieth, or outermost, about half-an-inch from it. By this means the wires are completely insulated from each other without the trouble of covering them with thread or varnish. The ends of wire project about two feet, for the convenience of connection. With one of my small cylindrical batteries, exposing about 150 square inches of total surface, this electro-magnet supports 400 lbs. I have tried it with a larger battery, but its energies do not seem to be so materially exalted as might have been expected by increasing the extent of galvanic surface. Much depends upon a proper acid solution; good nitric or nitrous acid, with about six or eight times its quantity of water, answers very well. With a new battery of the above dimensions and a strong solution of salt and water, at a temperature of 190° Fahr., the electro-magnet supported between 70 and 80 lbs., when the first seventeen coils only were in the circuit. With the three exterior coils alone in the circuit, it would just support the lifter, or cross piece. When the temperature of the solution was between 40° and 50°, the magnetic force excited was comparatively very feeble With the innermost coil alone, and a strong acid solution, this electro-magnet supports about 100 lbs.; with the four outermost wires, about 250 lbs. It improves in power with every additional coil until about the twelfth, but not perceptibly any further; therefore the remaining eight coils appear to be useless, although the last three, independently of the innermost seventeen, and at the distance of half-an-inch from the iron, produce in it a lifting power of 75 lbs.

"Mr. Marsh has fitted up a bar of iron much larger than mine, with a similar distribution of the conducting wires to that devised and so successfully employed by Professor Henry. Mr. Marsh's electro-magnet will support about 560 lbs. when excited by a galvanic battery similar to mine. These two, I believe, are the most powerful electro-magnets yet produced in this country.

"A small electro-magnet, which I also employ on the lecture table, and the manner of its suspension is represented by fig. 4. The magnet is of cylindric rod iron, and weighs four ounces; its poles are about a quarter of an inch asunder. It is furnished with six coils of wire in the same manner as the large electro-magnet before described, and will support upwards of 50 lbs.

"I find a triangular gin very convenient for the suspension of the magnet in these experiments. A stage of thin board, supporting two wooden dishes, fastened, at a proper height, to two of the legs of the gin. Mercury is placed in these vessels, and the dependent amalgamated extremities of the conducting wires dip into it—one into each portion.

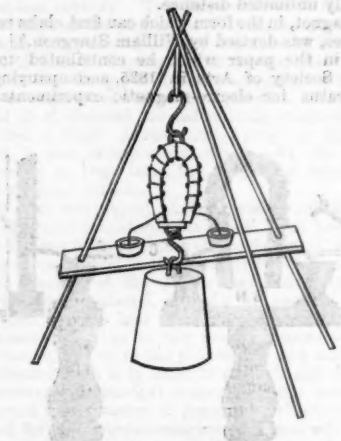


FIG. 4.—STURGEON'S LECTURE-TABLE ELECTRO-MAGNET.

"The vessels are sufficiently wide to admit of considerable motion of the wires in the mercury without interrupting the contact, which is sometimes occasioned by the swinging of the magnet and attached weight. The circuit is completed by other wires, which connect the battery with these two portions of mercury. When the weight is supported as in the figure, if an interruption be made by removing either of the connecting wires, the weight instantaneously drops on the table. The large magnet I suspend in the same way on a larger gin; the weights which it supports are placed one after another on a square board, suspended by means of a cord at each corner from a hook in the cross-piece, which joins the poles of the magnet.

"With a new battery, and a solution of salt and water, at a temperature of 190° Fahr., the small electro-magnet, fig. 3, supports 16 lbs."

In 1840, after Sturgeon had removed to Manchester, where he assumed the management of the "Victoria Gallery of Practical Science," he continued his work, and in the seventh memoir in his series of researches he wrote as follows:—

"The electro-magnet belonging to this Institution is made of a cylindrical bar of soft iron, bent into the form of a horse-shoe magnet, having the two branches parallel to each other, and at the distance of 4·5 inches. The diameter of the iron is 2·75 inches, it is 18 inches long when bent. It is surrounded by 14 coils of copper wire, seven on each branch. The wire which constitutes the coils is $\frac{1}{10}$th of an inch diameter, and in each coil there are about 70 feet of wire. They are united in the usual way with branch wires, for the purpose of conducting the currents from the battery. The magnet was made by Mr. Nesbit. . . . The greatest weight sustained by the magnet in these experiments is 12¾ cwt., or 1,386 lbs., which was accomplished by 16 pairs of plates, in four groups of four pairs in series each. The lifting power by 19 pairs in series was considerably less than by ten pairs in series; and but very little greater than that given by one cell or one pair only. This is somewhat remarkable, and shows how easily we may be led to waste the magnetic powers of batteries by an injudicious arrangement of its elements."*

At the date of Sturgeon's work the laws governing the flow of electric currents in wires were still obscure. Ohm's epoch-making enunciation of the law of the electric circuit appeared in "Poggendorff's Annalen" in the very year of Sturgeon's discovery, 1825, though his complete book appeared only in 1827, and his work, translated by Dr. Francis into English, only appeared (in Taylor's "Scientific Memoirs," vol. ii.) in 1841. Without the guidance of Ohm's law it was not strange that even the most able experimenters should not understand the relations between battery and circuit which would give them the best effects. These had to be found by the painful method of trial and failure. Pre-eminent amongst those who tried was Prof. Joseph Henry, then of the Albany Institute, in New York, later of Princeton, New Jersey, who succeeded in effecting an important improvement. In 1828,

* "I have made a number of experiments on small pieces, from the results of which it apears that much hammering is highly detrimental to the development of magnetism in soft iron, whether the exciting cause be galvanic or any other. And although good annealing is always essential, and facilitates to a considerable extent the display of polarity, that process is very far from restoring to the iron that degree of susceptibility which it frequently loses by the operation of the hammer. Cylindric rod iron of small dimensions may very easily be bent into the required form, without any hammering whatever; and I have found that small electro-magnets made in this way display the magnetic powers in a very exalted degree."

† Sturgeon's "Scientific Researches," p. 113.

* Sturgeon's "Scientific Researches," p. 188.

led on by a study of the "multiplier" (or galvanometer), he proposed to apply to electro-magnetic apparatus the device of winding them with a spiral coil of wire "closely turned on itself," the wire being of copper from $\frac{1}{30}$th to $\frac{1}{28}$th of an inch in diameter, covered with silk. In 1831 he thus describes * the results of his experiments :—

"A round piece of iron, about ¾ of an inch in diameter, was bent into the usual form of a horse-shoe, and instead of loosely coiling around it a few feet of wire, as is usually described, it was tightly wound with 35 feet of wire, covered with silk, so as to form about 400 turns; a pair of small galvanic plates, which could be dipped into a tumbler of diluted acid, was soldered to the ends of the wire, and the whole mounted on a stand. With these small plates the horse-shoe became much more powerfully magnetic than another of the same size, and wound in the same manner, by the application of a battery composed of 28 plates of copper and zinc, each eight inches square. Another convenient form of this apparatus was contrived by winding a straight bar of iron, 9 inches long, with 35 feet of wire, and supporting it horizontally on a small cup of copper containing a cylinder of zinc—when this cup, which served the double purpose of a stand and the galvanic element, was filled with dilute acid, the bar became a portable electro-magnet. These articles were exhibited to the institute in March, 1829. The idea afterwards occurred to me that a sufficient quantity of galvanism was furnished by the two small plates, to develop, by means of the coil, a much greater magnetic power in a larger piece of iron. To test this, a cylindrical bar of iron half an inch in diameter, and about 10 inches long, was bent into the shape of a horseshoe, and wound with 30 feet of wire; with a pair of plates containing only 2¼ square inches of zinc, it lifted 15 lbs. avoirdupois. At the same time, a very material improvement in the formation of the coil suggested itself to me on reading a more detailed account of Prof. Schweigger's galvanometer, and which was also tested with complete success upon the same horseshoe. It consisted in using several strands of wire, each covered with silk, instead of one. Agreeably to this construction, a second wire, of the same length as the first, was wound over it, and the ends soldered to the zinc and copper in such a manner that the galvanic current might circulate in the same direction in both, or, in other words, that the two wires might act as one. The effect by this addition was doubled, as the horseshoe, with the same plates before used, now supported 28 lbs.

"With a pair of plates four inches by six inches, it lifted 39 lbs., or more than fifty times its own weight.

"These experiments conclusively proved that a great development of magnetism could be effected by a very small galvanic element, and also that the power of the coil was materially increased by multiplying the number of wires without increasing the number of each." †

Not content with these results, Prof. Henry pushed forward on the line that he had thus struck out. He was keenly desirous to ascertain how large a magnetic force he could produce when using only currents of such a degree of smallness as could be transmitted through the comparatively thin copper wires, such as bell-hangers use. During the year 1830 he made great progress in this direction, as the following extracts show :—

"In order to determine to what extent the coil could be applied in developing magnetism in soft iron, and also to ascertain, if possible, the most proper lengths of the wires to be used, a series of experiments was instituted jointly by Dr. Philip Ten Eyck and myself. For this purpose 1,060 feet (a little more than one-fifth of a mile) of copper wire of the kind called bell wire, ·045 of an inch in diameter, were stretched several times across the large room of the Academy.

"*Experiment* 1.—A galvanic current from a single pair of plates of copper and zinc two inches square was passed through the whole length of the wire, and the effect on a galvanometer noted. From the mean of several observations, the deflection of the needle was 15°.

"*Experiment* 2.—A current from the same plates was passed through half the above length, or 530 feet of wire; the deflection in this instance was 21.

By a reference to a trigonometrical table, it will be seen that the natural tangents of 15° and 21° are very nearly in the ratio of the square roots of 1 and 2, or of the relative lengths of the wires in these two experiments.

"The length of the wire forming the galvanometer may be neglected, as it was only 8 feet long.

"*Experiment* 3.—The galvanometer was now removed, and the whole length of the wire attached to the ends of the wire of a small soft iron horse-shoe a quarter of an inch in diameter, and wound with abeut 8 feet of copper wire with a galvanic current from the plates used in Experiments 1 and 2. The magnetism was scarcely observable in the horseshoe.

"*Experiment* 4.—The small plates were removed, and a battery composed of a piece of zinc plate 4 inches by 7 inches, surrounded with copper, was substituted. When this was attached immediately to the ends of the 8 feet of wire wound round the horse-shoe, the weight lifted was 4½ lbs.: when the current was passed through the whole length of wire (1,060 feet) it lifted about half an ounce.

"*Experiment* 5.—The current was passed through half the length of wire (530 feet) with the same battery; it then lifted two ounces.

"*Experiment* 6.—Two wires of the same length as in the last experiment were used, so as to form two strands from the zinc and copper of the battery; in this case the weight lifted was four ounces.

"*Experiment* 7.—The whole length of the wire was attached to a small trough on Mr. Cruikshank's plan, containing 25 double plates, and presenting exactly the same extent of zinc surface to the action of the acid, as the battery used in the last experiment. The weight lifted in this case was 8 oz.; when the intervening wire was removed, and the trough attached directly to the ends of the wire surrounding the horseshoe, it lifted only seven ounces. . . . .

"It is possible that the different states of the trough, with respect to dryness, may have exerted some influence on this remarkable result; but that the effect of a current from a trough, if not increased, is but slightly diminished in passing through a long wire is certain. . . . .

"But, be this as it may, the fact that the magnetic action of a current from a trough is, at least, not sensibly diminished by passing through a long wire is directly applicable to Mr. Barlow's project of forming an electro-magnetic telegraph; and it is also of material consequence in the construction of the galvanic coil. From these experiments it is evident that in forming the coil we may either use one very long wire or several shorter ones, as the circumstances may require; in the first case, our galvanic combinations must consist of a number of plates, so as to give 'projectile force;' in the second it must be formed of a single pair.

"In order to test on a large scale the truth of these preliminary results, a bar of soft iron, 2 inches square and 20 inches long, was bent into the form of a horseshoe, 9½ inches high; the sharp edges of the bar were first a little rounded by the hammer, it weighed 21 lbs.; a piece of iron from the same bar, weighing 7 lbs., was filed perfectly flat on one surface, for an armature or lifter; the extremities of the legs of the horse-shoe were also truly ground to the surface of the armature; around this horseshoe 540 feet of copper bell-wire were wound in 9 coils of 60 feet each; these coils were not continued around the whole length of the bar, but each strand of wire according to the principle before mentioned, occupied about two inches, and was coiled several times backward and forward over itself; the several ends of the wires were left projecting and all numbered, so that the first and last end of each strand might be readily distinguished. In this manner we formed an experimental magnet on a large scale, with which several combinations of wire could be made by merely uniting the different projecting ends. Thus if the second end of the first wire be soldered to the first end of the second wire, and so on through all the series, the whole will form a continued coil of one long wire.

"By soldering different ends the whole may be formed into a double coil of half the length, or into a triple coil of one-third the length, &c. The horseshoe was suspended in a strong

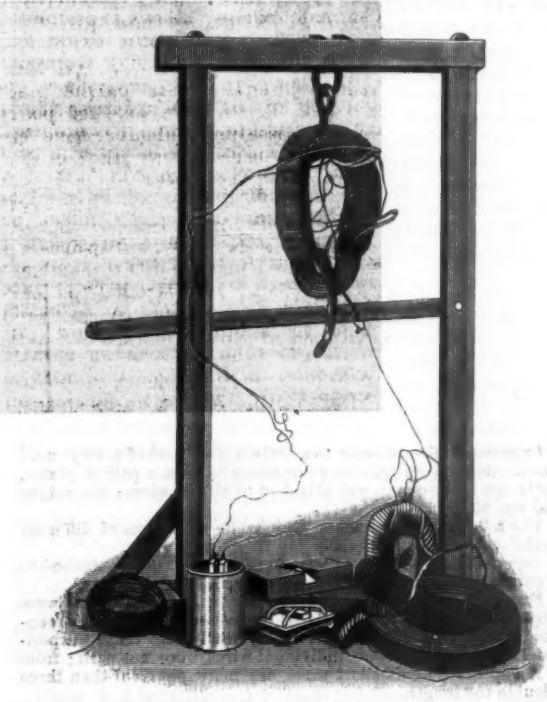


FIG. 5.—HENRY'S ELECTRO-MAGNET.

This figure, copied from the *Scientific American*, December 11th, 1880, represents Henry's electro-magnet, still preserved in Princeton College. The other apparatus at the foot, including a current-reverser, and the ribbon-coil used in the famous experiments on secondary and tertiary currents, were mostly constructed by Henry's own hands.

* Silliman's "American Journal of Science," January, 1831, xix., p. 400.

† "Scientific Writings of Joseph Henry," p. 39.

rectangular wooden frame, three feet nine inches high and twenty inches wide, an iron bar was fixed below the magnet, so as to act as a lever of the second order; the different weights supported were estimated by a sliding weight in the same manner as with a common steel-yard (see sketch). In the experiments immediately following (all weights being avoirdupois) a small single battery was used, consisting of two concentric copper cylinders with zinc between them; the whole amount of zinc surface exposed to the acid from both sides of the zinc was ¼th of a square foot; the battery required only half a pint of dilute acid for its submersion.

"*Experiment* 8.—Each wire of the horseshoe was soldered to the battery in succession, one at a time; the magnetism developed by each was just sufficient to support the weight of the armature, weighing 7 lbs.

"*Experiment* 9.—Two wires, one on each side of the arch of the horseshoe, were attached; the weight lifted was 145 lbs.

"*Experiment* 10.—With two wires, one from each extremity of the legs, the weight lifted was 200 lbs.

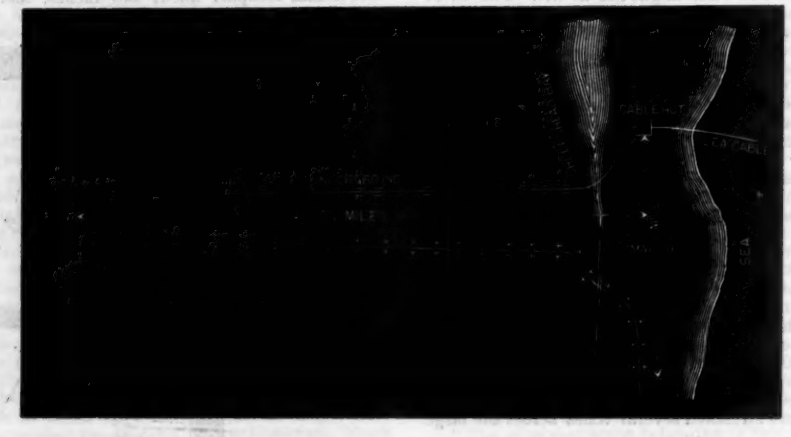
"*Experiment* 11.—With three wires, one from each extremity of the legs and one from the middle of the arch, the weight supported was 300 lbs.

Experiment 12.—With four wires, two from each extremity, the weight lifted was 500 lbs. and the armature; when the acid was removed from the zinc, the magnet continued to support for a few minutes 130 lbs.

"*Experiment* 13.—With six wires the weight supported was 570 lbs.; in all these experiments the wires were soldered to the galvanic element; the convexion in no case was formed with mercury.

Experiment 14.—When all the wires (nine in number) were attached, *the maximum weight lifted was* 650 *lbs.*, and this astonishing result, it must be remembered, was produced by a battery, containing only ¼ths of a square foot of zinc surface, and requiring only half a pint of dilute acid for its submersion.

Experiment 15.—A small battery, formed with a plate of zinc 12 inches long and 6 inches wide, and surrounded by copper, was substituted for the galvanic elements used in the last experiment; the weight lifted in this case was 750 lbs.



"*Experiment* 16.—In order to ascertain the effect of a very small galvanic element on this large quantity of iron, a pair of plates, exactly one inch square, was attached to all the wires; the weight lifted was 85 lbs.

"The following experiments were made with wires of different lengths on the same horseshoe.

"*Experiment* 17.—With six wires, each 30 feet long, attached to the galvanic element, the weight lifted was 375 lbs.

"*Experiment* 18.—The same wires used in last experiment were united so as to form three coils of 60 feet each; the weight supported was 290 lbs. This result agrees nearly with that of experiment 11, though the same individual wires were not used; from this it appears that six short wires are more powerful than three of double the length.

"*Experiment* 19.—The wires used in Experiment 10, but united so as to form a single coil of 120 feet of wire, lifted 60 lbs.; while in Experiment 10 the weight lifted was 200 lbs.; this is a confirmation of the result in the last experiment. . . . .

"In these experiments, a fact was observed which appears somewhat surprising; when the large battery was attached, and the armature touching both poles of the magnet, it was capable of supporting more than 700 lbs., but when only one pole is in contact it did not support more than 5 or 6 lbs., and in this case we never succeeded in making it lift the armature (weighing 7 lbs.). This fact may perhaps be common to all large magnets, but we have never seen the circumstance noticed of so great a difference between a single pole and both. . . . .

"A series of experiments was separately instituted by Dr. Ten Eyck, in order to determine the maximum development of magnetism in a small quantity of soft iron.

"Most of the results given in this paper were witnessed by Dr. L. C. Beck, and to this gentleman we are indebted for several suggestions, and particularly that of substituting cotton well waxed for silk thread, which in these investigations became a very considerable item of expense. He also made a number of experiments with iron bonnet wire, which being found in commerce already wound, might possibly be substituted in place of copper. The result was that with very short wire the effect was nearly the same as with copper, but in coils of long wire with a small galvanic element it was not found to answer. Dr. Beck also constructed a horseshoe of round iron one inch in diameter, with four coils on the plan before described. With one wire it lifted 30 lbs., with two wires 60 lbs., with three wires 85 lbs., and with four wires 112 lbs. While we were engaged in these investigations, the last number of the *Edinburgh Journal of Science* was received containing Professor Moll's paper on 'Electro-Magnetism.' Some of his results are in a degree similar to those here described; his object, however, was different, it being only to induce strong magnetism on soft iron with a powerful galvanic battery. The principal object in these experiments was to produce the greatest magnetic force with the smallest quantity of galvanism. The only effect Prof. Moll's paper has had over these investigations has been to hasten their publication; the principle on which they were instituted was known to us nearly two years since, and at that time exhibited to the Albany Institute."*

(*To be continued.*)

POLARISATION OF THE EARTH BY HEAVY CURRENTS.†

By CHARLES CUTTRISS.

WHILE investigating further the causes of the disturbances experienced when testing the Commercial Cable Company's cable which lands at Coney Island, an account of which will be found in the *Electrical Engineer* of August 6th,‡ certain phenomena have been noticed which may be interesting as showing the effect of heavy currents in polarising the ground when it is used as a return circuit for an electric road, and also the great distance at which such effects are felt.

On Sunday, August 17th, an attempt was made from my office in the Drexel Building, New York, to take the usual weekly test of the condition of the cable, but without success, as, owing to the violent and erratic movements of the mirror, it was impossible to get a reliable reading. It was then determined to measure, if possible, the differences of potential that caused such disturbances. In order to make the method of procedure clear, it will be well to state that the underground circuits of the company extend from Wall Street in a northerly direction to the Bronx River, a distance of about 12 miles, and in a southerly direction to Coney Island, also about 12 miles. As there is nothing to my knowledge in the vicinity of the Bronx River terminus to cause any electrical disturbance of the earth's potential, the grounding at that station and at Coney Island of one of their wires gives a very ready way of detecting in New York any variations of potential that may take place at either end.

The first series of experiments were made between

* Scientific Writings of Joseph Henry, p. 49.

† *Electrical Engineer*, of New York.

‡ See ELECTRICAL REVIEW for August 23nd.

the hours of 10.45 a.m. and noon of August 17th, and showed that between Bronx River and New York there was a fairly steady difference of potential of from ·8 to 1 volt; but between New York and Coney Island there was a difference of potential varying rapidly from ·1 to 3·5 volts, the extreme fluctuations often occurring in four or five seconds. The potential difference between Bronx River and Coney Island was about the same as between New York and Coney Island, or perhaps a trifle higher, and also very unsteady.

It was useless to do anything more until the electric road closed down, so the experiments were abandoned till midnight. At 12.25 a.m. I found a very heavy current between Coney Island and New York, but could not detect the running of any cars. Measurements now showed a positive difference of potential of 4·5 volts; this remained fairly steady till about 1 a.m., when the potential commenced to fall slowly and steadily. At 1.15 a.m. the galvanometer denoted an equal potential at both ends of the line, but the movement of the mirror still continued, slowly crossing the zero and indicating an opposite, or negative, potential wave, which by 1.25 a.m. had reached 3·5 volts negative. It then began to drop, reaching zero at 1.40 a.m., and continued on until it showed a positive difference of ·8 volt, where it remained steady, showing that the earth at Coney Island had become normal, as the difference of ·8 volt corresponded with the reading between New York and Bronx River. I might state that the New York ground potential was checked off by the Bronx River circuit every five minutes in order to make sure that the variations were not due to local causes.

From the results obtained in the above experiments it is quite evident that there is an actual polarisation of the ground for an unknown distance from the rails of the electric road. The accompanying diagram will make clear the relative positions of the electric road and the ocean cable. The first long, positive (+) current, I think, must be caused by a direct flow of current from the rails through the sea and across the marsh and Sheepshead Bay to the sheathing of the cable; consequently, when the current is cut off from the rails, this direct current gradually drops, and as the current due to the polarisation asserts itself, for an instant the ground at the point of connection between the conductor and sheathing becomes neutral from the action of equal and opposite forces. But, as the negative current from the ground surrounding the cable discharges along the sheathing, that being the path of least resistance, it produces a negative potential at the end of the conductor, which rises to a maximum in a few minutes, and then gradually dies away as the condition of the ground becomes normal. If the normal condition of the ground can thus be raised 4·3 volts by a disturbing force at a distance of ½ mile, the close proximity of these two systems would certainly render the practical working of the weaker one—the cable—almost an impossibility, even if, as suggested by Mr. T. D. D. Lockwood, a duplicate cable were to be laid, as it is mechanically impracticable to construct two cables in which the dielectric resistance, copper resistance, and capacity shall be identical. Consequently, a variation in either of these respects must make itself manifest when the cores are subjected for a considerable distance to violent and rapid electrical strains.

The great difference in this problem over that of equalising telephone or telegraph circuits rests in the extreme delicacy of the receiving apparatus, and the enormous electrostatic capacity of long lengths of submarine cable.

New York Subway Work.—The Board of Electrical Control met on August 22nd, in the Mayor's office, and received a report from the Construction Company, which shows the work of burying the wires is going on satisfactorily. The report states that, in 1889, 56,035 feet of subway and 621,430 feet of ducts were laid. Up to the month of August, 1890, 158,181 feet of trench have been dug, and 774,926 feet of ducts laid.

NOTES.

The Bradford Corporation Lighting.—At the meeting of the council, last week, in reply to a question about the electric lighting work, Alderman Priestman said, with regard to the electricity works, that he had given a statement of the loss accrued to December 31st last, and he hoped to present a statement at the end of the present year. So far, the loss was short of £1,000. The electrical department had never been expected to pay in its earlier stages. An engine was now being laid down which would increase the output without augmenting the working cost, and he expected that in a few months the statement would be very much better than it would be if presented now. If the council would appropriate a sum of, say, £10,000 from the profits of the gas department for the benefit of the electric lighting works, they could be made to pay their way. With regard to the mains and services, which stood at the large sum of £177,000, he believed they had value for every penny of the money. He hoped that ere long the committee would be able to show that the electric lighting department was paying its way; but if not, it would be necessary to raise the price to the consumer. There was no cause to regret the steps taken in respect to this question. He had not the least doubt that if they had not taken the powers of supply themselves, they would have had to spend a great deal more money in keeping other people out. The minutes were then adopted.

Electric Lighting at Fareham.—The completion of the electric lighting installation at Fareham was celebrated on Thursday evening by a banquet, which was given by Capt. Ramsay and the directors of the local electric lighting company to the principal residents of the town and neighbourhood. The dining-room at the Red Lion was lighted in honour of the occasion by numerous small incandescent lamps, which hung from the ceiling. The street poles, with regard to which an indictment is pending against the company, have been adorned with paint, and can no longer be said to constitute an eyesore, while the lighting by electricity of the main thoroughfares has given general satisfaction to the inhabitants.

Portsmouth and the Electric Light.—No definite steps have yet been taken with regard to the introduction of the electric light into Portsmouth by the Corporation, but the committee recently appointed is engaged in collecting information which will be embodied in its report to the council. In all probability the Corporation will decide to obtain its own provisional order, and afterwards sub-let its rights for a short period to the highest bidder among the rival electric companies who are anxious to make a start in the town, but have hitherto been foiled by the "dog-in-the-manger" policy of the municipality. It is whispered that some time since an effort was made to induce the directors of the Portsmouth Gas Company to take up electricity, but they declined, and now it is too late.

Church Lighting.—An installation of the electric light is at present being carried out at the Church and Parochial Hall of St. John's the Divine, Vassall Road, Brixton. About 300 incandescent lamps will be used. The plant consists of a gas engine, a dynamo, and a set of accumulators; a motor is also being put down for blowing the organ of the church electrically.

Electric Lighting at Barnsley.—The Barnsley Corporation have adjourned the matter of the electric light to enable the Thomson-Houston Company to send in a complete tender. It is probable that although that of the Westinghouse Company was accepted the contracts may not be signed. Several members of the committee have recently visited various central stations, and are so favourably impressed with the Thomson-Houston system that it seems likely that it will prevail.

Prague Electric Lighting.—At the end of last year the electric lighting installations in Prague comprised 8,365 incandescence lamps and 143 arc lights, distributed among various factories, theatres and restaurants. The current was obtained from 47 dynamos of a total capacity of 425 kilowatts. Steam engines and gas engines supplied the motive power, the gas engines being in the proportion of 23 per cent.

Faraday & Son.—The firm of Faraday & Son, of Berners Street, was one of the first to devote special attention to the production of decorative fittings suitable for lighting by electricity. Their book of designs has gradually grown in size, and the new edition, now being issued, consists of 62 pages of drawings representing brackets, pendants, electroliers, coronæ, standards, figures, hall lanterns, portable lamps, and billiard lights, the registered designs of which, numbering nearly 100, are the property of the firm.

Holden & Brooke.—Messrs. Holden and Brooke, of Manchester, have issued a new catalogue, containing several new specialities and the latest developments in exhaust and live steam injector practice. It also gives a series of self-explanatory drawings of injectors fitted up under various conditions, with such instructions as would enable purchasers abroad to know exactly what to order for their requirements.

Britannia Company.—We have received catalogue No. 3 from the Britannia Company, consisting of descriptions, illustrations and prices of engineers' tools and amateurs' lathes. The prices, however, are modified by the notice (which so frequently accompanies trade lists now-a-days) that, in consequence of the continued advance in the cost of raw material and wages, all quotations and discounts are from this date withdrawn.

W. T. Goolden & Co.—This firm has issued a useful little pamphlet, entitled "Electricity in Every-day Life," explaining the advantages of electric lighting and the transmission of power by electric motors for pumping, ventilating, hoisting, drilling, and a variety of other operations. The illustrations are all representations of appliances that have been actually constructed and set up, and that have proved perfectly successful under ordinary working conditions.

Sunbeam Lamp.—A new price list is issued of the sunbeam lamp, which has been found in practice to be specially adapted for lighting large halls, exhibitions, saloons and decks of ships, and similar places. It is pointed out that, with the same engine and dynamo power, nearly double the light can be obtained from this lamp, as compared with groups of small glow lamps; and, compared with arc lamps in opal globes, the sunbeam gives nearly two-thirds the light, is absolutely steady (never falling momentarily in brightness, as does the arc), requires no attention, and is pleasanter in colour.

Phosphor-Bronze Company.—We have been favoured with an early copy of the latest descriptive catalogue and pamphlet issued by the Phosphor-Bronze Company. It is stated in the introduction that the company's cog-wheel brand of alloys of phosphor-bronze have been in extensive use for 20 years. The use of phosphor-bronze wire, and especially of Weiller's patent siliciumbronze wire, for telegraph and telephone purposes, has been attended with the most important results, especially as regards the danger of overhead wires and the cost of renewals. Long telegraph lines, for which iron wire, weighing 400 lbs. per mile, was formerly used, is replaced by bronze wire weighing only 100 lbs. per mile, while for telephone lines bronze wire of 38 lbs. per mile has been used where formerly the wire weighed 240 lbs. per mile. The wire being smooth and light, and offering very little surface to wind and snow, is unaffected by the severest storms, so that its use does away with the danger of falling wires and the inconvenience of interrupted communication.

Electrical Tramways at Boston.—The West End Electrical Tramway of Boston, U.S., is the largest system, worked by electricity, in the world. There are about 260 miles of line, with 1,600 cars. Until recently these tramways were worked by horses, but experiments in electric traction, carried out by the Thomson-Houston Company, resulted so satisfactorily that horses were done away with altogether, and electricity substituted in their place. The station is the largest electrical one existing, the boiler-house being 160 feet in length by 80 feet in width, and the dynamo room about twice these dimensions. There will be 13 Corliss engines of 1,750 H.P. each, driving 300 H.P. dynamos. The wires are overhead, and it would surprise those who object to this method on the ground of unsightliness to know how little the wires and poles are noticeable.

The Schanschieff Electric Light and Power Company, Limited.—Notice is given, that a general meeting of the members of the above-named company will be held at 32, Poultry, at two o'clock, on 17th October next, for the purpose of having the accounts of the liquidation, showing the manner in which the winding up of the affairs of the company has been conducted, and the property of the company disposed of, laid before the company, and hearing any explanation that may be given with refrence thereto; and for the purpose of considering such accounts, and, if the same shall be approved, of passing a resolution approving the same; and also of determining, by extraordinary resolution, the manner in which the books, accounts, and documents of the company, and the liquidation thereof, shall be disposed of.—S. DE LISSA, liquidator.

Australian Cable.—It is stated by the Press Association that Lord Knutsford has addressed a letter, dated July 9th, to the Governor of South Australia, setting forth the reasons why Her Majesty's Government have refused to comply with the request of the Australian Governments that the Imperial Exchequer should bear a share of the guarantee and subsidies which are necessary to allow the cable companies to reduce their rates to Australia. The letter states that the Agents-General have very fully explained, and have ably supported, the views of their Governments in this matter. The Imperial Government fully sympathise with the object of the subsidy, and recognise the nature and extent of the sacrifices which the Australian colonies are prepared to make with a view of developing and facilitating telegraphic communication. The readiness with which the colonies accepted, at the risk of considerable loss of revenue, the proposal of the Chancellor of the Exchequer for a reduction of the postal rates affords additional reason for the most favourable consideration of any proposal emanating from their incognate matters.

American Electric Transit Statistics.—The Census Bureau of America has issued a bulletin which gives interesting information as to transit facilities of the country. The relation between electricity and other motive powers shows the former to have reached a fairly good figure. The figures run :—

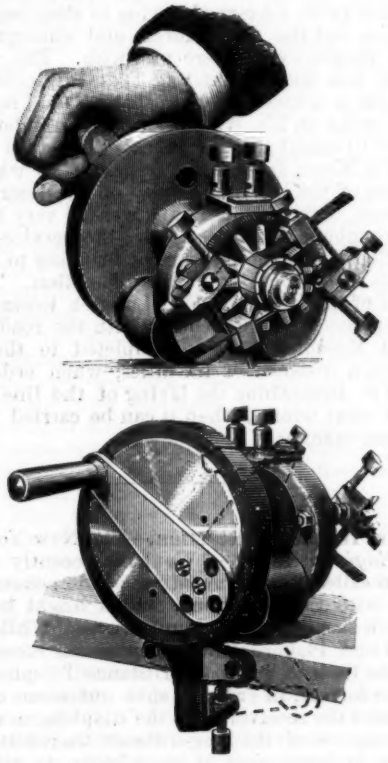
Miles of horse railway	5,902½
„ electric	1,753
„ dummy	556
„ cable	441
Total mileage...	8,652½

Electricity has, therefore, more than 25 per cent. of the total mileage.

Appointment.—Mr. Edward A. O'Keeffe, B.E., has been appointed Senior Demonstrator and Lecturer at the City and Guilds of London Technical College, Finsbury, in the place of Mr. W. Robinson, the newly-appointed Professor of Engineering at University College, Nottingham.

Lectures on Electric Meters.—A course of six lectures on electric meters, by Prof. Silvanus Thompson, is announced to commence in October at the Finsbury Technical College. This is one of the occasional short courses of lectures which each of the Finsbury professors undertakes annually. The electric lighting arrangements of the college have been lately overhauled and improved. A new Kapp dynamo has replaced the Edison machine formerly employed.

Austin's "Novel" Hand Dynamo.—This hand-dynamo has been specially designed for experimental work, either in the laboratory or on the lecture table, for which it is admirably adapted, as from the manner in which it is wound, it will work under all circumstances; no matter whether the external resistance be high or low, the machine will give out a corresponding quantity of current. Great care has been taken in the construction of these machines, so that as much as possible of the manual work expended in turning the



handle is given out at the terminals as electrical energy. As will be seen from the illustrations, the machine is very compact, and has a pleasing appearance. Its output is equal to about six or eight quart Bunsen cells. The machine all complete weighs only 16 lbs. It can be fixed either temporarily or permanently to bench or table. Six different leverages can be got by altering position of handle, three of the most important being shown by dotted lines. There are no belts, cords, or cogwheels used in gearing, which is constructed entirely of metal, working on the principle of rollers and traction—there is consequently very little friction. There are no complicated parts, every part being constructed in the simplest manner possible, and the material and workmanship are of the best.

The Loan for Electric Lighting at Dublin.—Mr. Charles P. Cotton, C.E., Board of Trade Inspector, held an inquiry at Dublin last week with reference to an application of the town authorities for a loan of £50,000 for the purpose of an installation for the supply of electricity. The inspector is preparing a report on the evidence.

Killed by Electricity.—The *Times* New York correspondent says:—A terrible electric light accident occurred at a theatre here on Monday night. While a lineman was adjusting some wires for illuminating the front of the theatre, he accidentally established a connection, and, receiving the full force of the current, was killed on the spot. The accident caused a most painful impression among a large number of persons who were watching the man's operations.

The *Evening News and Post*, in referring to this matter, says:—"The circumstances will tend strongly to discredit the new system of execution in that State." . . . . "The fact that such torture as this man suffered is possible for a full ten minutes without life being extinguished, shows that electricity is not to be relied upon as a painless method of killing." Surely our evening contemporary does not imagine that the process of electrical execution is to suspend culprits from wires, and let them roast? Moreover, the incidents peculiar to this case had happened previously to Kemmler's fate, so it is rather late in the day to pen comments of this nature.

The Telephone on the Congo.—The *Ville de Maranaho*, of the Walford Company of Antwerp, which has just sailed for the Congo, carries all the material necessary for the installation of the first telephone line which is to be placed along the Congo railway. The wires are of phosphor-bronze, and the apparatus is on the Dejongh system, made by Mourlon, of Brussels, with magneto bells of the model adopted, after a competition, by the Administration of Belgian Posts for its private lines, &c.

Stockholm Electric Lighting.—The following circular has been sent to members of the Electrical Trade Section of the London Chamber of Commerce by the secretary:—"Having been advised that the notice which appeared in the electrical papers, that the date for the presentation of tenders for the lighting by electricity of the town of Stockholm had been extended from the 15th September to the 12th October, was erroneous, I have, at the request of the chairman of the Electrical Section, and after consultation with the Foreign Office and the Swedish Consul in London, communicated officially with the Stockholm Gas Works. In reply, I have received official telegraphic intimation from that body in language which is considered sufficiently satisfactory, that tenders for the electric lighting contract at Stockholm, *posted from this country not later than the 20th inst., will be considered.*"

Charterhouse Science and Art Schools and Literary Institute.—The winter session of this, one of the largest Science and Art Schools in the United Kingdom, and a school which has trained some thousands of teachers for the office of science lecturers, will commence on Saturday, September 27th, 1890, under the presidency of the Rev. Henry Swann, M.A. During the late session about 900 students, mostly elementary teachers, availed themselves of the privileges afforded by this institution, and of this number above 700 presented themselves for examination, and were successful in obtaining a large number of first-class certificates, and also several honors' certificates awarded by the Science and Art Department of South Kensington. Students who were prepared for the Lond. B.Sc. (Inst.) highly distinguished themselves. A National Scholarship of £150 was awarded to one of the female students of the Art school. Instruction of a practical character is given in most of the sciences at a very nominal fee. Students who aim at becoming proficient in chemistry (organic and inorganic) have the opportunity of working in a well-fitted laboratory, capable of accommodating 60 students. Full particulars of the classes may be obtained from C. Smith, organising secretary.

The Electric Light in Textile Factories.—In a recent number of *L'Electricien* the arrangement of the electric light in spinning and weaving mills is discussed. For spinning white, unbleached, or clear-coloured yarns in high rooms, the proportion is given of one 12-ampère arc light to 230 square yards, that is 15 by 15 yards. For a 9 or 10-ampère arc the area should not exceed 110 square yards, or 10½ by 10½ yards. For weaving, a minimum lighting power of a 12-ampère arc to 133 square yards, or 11½ by 11½ yards, is given. For white, unbleached, or clear colours, a 10-ampère arc should be sufficient for an area of 93 square yards, say 9½ by 9½ yards; but for black, or dark colours, it is often found necessary to allow only 59 square yards for each 10-ampere arc. In weaving light goods by incandescence lamps, a 10-candle lamp may be used for two looms with unbleached stuff, but when working in coloured yarns two 16-candle lamps are required per loom, and should this be a long one, two 20-candle lamps. These figures appear to be taken from actual experience in Belgium and Germany, but as nearly every factory has a different arrangement of rooms and machinery, the amount of lighting required will not depend so much upon the area of the rooms as upon the method necessary to sufficiently illuminate each particular machine or separate portion of work.

Elmore's French Patent Copper Depositing Company, Limited.—This company has been formed to work the process of the Messrs. Elmore in France, with a capital of £200,000 in 100,000 shares of £2 each. 66,750 shares were offered to the public at a premium of 10s. per share. The board of directors includes Sir Richard J. Meade, Major Charles Jones, E. J. Carson, Wm. Elmore, Charles Glendinning Philips, and Sir James D. Mackenzie, Bart. The patents were to be sold to this company by Elmore's Foreign and Colonial Patent Copper Depositing Company for £83,500 cash, £66,500 in shares, and the premiums on the shares (assuming the shares were all taken up), amounting to £33,275, the vendors thus benefiting to the extent of £183,275. The working capital will be £50,000.

Fraud by a Telegraphist.—Herbert Wadsworth, assistant postmaster at Milnsbridge, was fined £2 and costs by the West Riding magistrates at Huddersfield on Monday, in each of two cases for wilfully and without due authority altering telegrams with intent to defraud Her Majesty's Postmaster-General. In consequence of complaints as to alterations of telegrams going from this office, a clerk from London was sent on August 28th to make inquiries. This gentleman handed in two telegrams at the Gobar office addressed to different people in Bradford, and containing 58 words. Upon these 2s. 5d. was paid. Defendant condensed messages, and by sending them as duplicates only, placed 1s. 3½d. upon them in stamps, pocketing the difference.

The American Association for the Advancement of Science.—Professor Nipher is credited with having described a new method of measuring the electrical resistance of liquids before this Society (see page 339). We would like to ask wherein this differs from that devised years ago by Wheatstone, whose apparatus also reversed the galvanometer at the same time? This so-called new method appears to be periodically revived, as we have previously pointed out.

Blasting by Means of Electricity.—The work of blowing up the masses of rock which form the dangerous rapids known as the Iron Gates, on the Danube, was commenced on Monday near Greben, M. Baross, the Hungarian Minister of Commerce, firing the first charge by means of electricity.

The Telegraph in the Chin-Lushai Expedition.—His Excellency the Governor-General of India, in Council, is glad to acknowledge, through a general order dated September 8th, 1890, the services of Mr. E. O. Walker, Assistant-Superintendent of Telegraphs, and his department, and of Mr. G. Barton Groves, Deputy Inspector of Post Offices, and the Postal Department.

A despatch of the Adjutant-General in India, dated July 16th, states:—The Telegraph Department worked extremely well throughout the expedition.

Lieut.-General B L. Gordon, C.B., commanding the Burnia district, in a despatch to the Adjutant-General, Madras, dated May 28th, says:—The Telegraph Department has worked well, under many difficulties of transport labour and sickness. The construction of the line kept pace with the advance of the troops into Haka. The wire has been invaluable throughout the operations.

In a despatch dated 31st May, addressed to the Adjutant-General, Brigadier-General V. W. Tregear, commanding the Chillagong column, states:—The whole of the field work has proved laborious and exhausting to all concerned, owing to steep ascents and declivities, and the dense forest and undergrowth, or bamboo jungle, everywhere met with. The whole of the work has, notwithstanding these difficulties, been carried out in a most excellent manner, and reflects the greatest credit on Mr. Walker and all his subordinates. Owing to ill-health, Mr. Walker had to return to India on the 7th March from Fort Tregear, after which date the laying of the line was carried on by Messrs. Rector and Davies, both of whom have worked very hard and well throughout the expedition; the services of the latter officer I had the pleasure of bringing to notice in my final report on last year's expedition. The construction of the line from Fort Lungleh towards Haka was commenced simultaneously with the road, and by the 23rd March had been completed to the Upper Kolodyne, a distance of 65 miles, when orders were received to discontinue the laying of the line towards Haka till next winter, when it can be carried out in a permanent manner.

A Novel Telephonic Reaction.—The New York *Electrical Engineer* says:—"We have recently had our attention called to an interesting phenomenon in connection with the telephone, which might be looked upon with suspicion by the uninitiated. While Messrs. Hibbard and Pickernell were conversing recently over one of the lines of the Long Distance Telephone Company, the former, in order to shut out some conversation, placed the receiver with the diaphragm end over the mouthpiece of the long-distance transmitter. The receivers at both ends at once began to give ou at musical sound, which continued until the receiver was withdrawn from the mouthpiece of the transmitter. Investigation proved that the effect was due to an action quite similar to that employed in the well-known buzzer, or vibrating bell. An original impulse imparted to the transmitter is conveyed electrically through the primary and secondary circuits to the receiver, which in turn throws it back upon the transmitter through the intervening air, thus constituting a complete electric and acoustic cycle. This battledore and shuttlecock action between receiver and transmitter is continuous as long as the receiver is held against the transmitter, and gives rise to a musical note of high pitch and great uniformity. Of course, it requires a powerful transmitter to produce the phenomenon, the ordinary Blake instrument being incapable of demonstrating it. The effect produced is decidedly novel, and the experiment is well worthy of repetition." We may remark that the experiment is not novel, a precisely similar one having been made several years ago by Mr. Ströh, in the early days of the telephone and microphone; the microphone used was of small dimensions, and was mounted on a diaphragm of gold-beater's skin.

Personal.—We understand that Mr. Albright sails to-morrow in the *Servia* with the members of the Iron and Steel Institute, who are about to visit America.

NEW COMPANIES REGISTERED.

Elmore's French Patent Copper Depositing Company, Limited.—Capital £200,000 in £2 shares. Objects: To adopt an agreement between Elmore's Foreign and Colonial Patent Copper Depositing Company, Limited, of the first part, Woodhouse & Rawson United, Limited, of the second part, and this Company of the third part. To carry on in France, and elsewhere, the business of manufacturers of and dealers in copper and other metals, all metallic alloys or compounds of the same, and all goods or articles made of copper or other metals and alloys. To carry on business as electricians, electrical contractors, electrical and mechanical engineers, and suppliers of electricity for the purposes of light, heat, sound, power or otherwise, and of manufacturers of and dealers in all apparatus and things required for the generation, distribution, supply, accumulation and employment of electricity. Signatories (with one share each), A. L. Brockman, 8, The Avenue, Brondesbury; T. E. Marsh, 42, Reighton Road, Upper Clapton; J. North (engineer), 88, Queen Victoria Street; S. Rentall, 121, Vassall Road, Brixton; J. Mumford, 50A, Trinity Square, Borough; J. Moore, 46, Norroy Road, Putney; F. Dewer Summers, 31, Berwick Street, S.W. The signatories are to appoint the first directors. Qualification: 200 shares, or £500 stock. Until otherwise determined by the company in general meeting, the remuneration of the board is to be £200 per annum for each director, with an additional £200 per annum for the chairman, and £100 for the vice-chairman, together with 2½ per cent. commisssion upon the net profits from manufacturing and upon the revenue accruing from licensing or sub-licensing the Company's patents, and 1 per cent upon net profits from sale of patents, such commission to be divided as the directors think fit. Registered 10th inst. by Wm. Brown, 18, St. Swithin's Lane, secretary.

Service and Company, Limited.—Capital £6,000, in £5 shares. Objects: To acquire the business of wholesale and retail ironmonger, carried on at 4, The Octagon, Plymouth; to carry on (if thought wise) the business of an electric light company in all branches, and to supply electricity for light, heat, motive power, or otherwise; and to manufacture and deal in electrical apparatus generally. Signatories (with 1 share each): W. H. Luke, F. S. Willies, A. Yeo, A. N. Cole, T. B. Percy, all of Plymouth; J. Snawdon, Pennycomequick; R. W. C. Barker, Stonehouse. The remuneration of the directors is to be determined by the company in general meeting. Qualification: £125 in shares. Registered 10th inst. by Sir Joseph Causton and Sons, 9, Eastcheap, as agents for Bond and Pearce, Solicitors, 16, Princess Square, Plymouth.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Electric Installation and Maintenance Company, Limited.—An agreement of 25th ult., filed 12th inst., cites that the Electric Construction Corporation, Limited, has carried out an electric installation at Nos. 19 and 20, Walbrook, and is supplying electricity to various customers in the neighbourhood. This company agrees to purchase the said installation and the plant, materials, &c., in connection therewith, for £2,390, payable as to £950 in 6 per cent. debentures and the balance by the allotment to the vendor company of 144 fully paid £10 shares in this company.

Syndicate of Electrical Engineers, Limited.—The statutory return of this company, made up to the 7th February, was filed on the 8th ult. The nominal capital is £10,000, divided into 1,900 ordinary and 100 founders' shares of £5 each. 607 shares have been taken up, and the full amount has been called thereupon. The calls paid amount to £600, and unpaid to £7. Registered office, 15, St. Helen's Place.

Earthy Metals Company, Limited.—The registered office of this company is at No. 1, Westbourne Terrace, Willesden Green.

Mulholland, Maugham & Company, Limited.—The registered office of this company is situate at West Cornforth, R.S.O., Ferryhill, Durham.

Edison Phonographic Toy and Automaton Company, Limited.—The registered office of this company is at 2, Metal Exchange Buildings, Gracechurch Street.

CITY NOTES.

The Electric and General Investment Company.

THE first ordinary general meeting of this company was held on Tuesday afternoon last, at the offices, Nos. 1 and 2, Great Winchester Street, Old Broad Street, under the presidency of Mr. John Herring.

Mr. J. Cecil Bull (the secretary) read the notice convening the meeting, which stated that it was merely a statutory meeting held in accordance with the requirements of the Companies' Acts, and that there would be no business transacted.

The Chairman remarked that although it was only a formal statutory meeting, it was usual for something to be said on such occasions, either as to the business actually done by the companies or their prospects. He was able to state that the directors had had brought under their notice a considerable number of schemes, some of which looked good, whilst others the board had dismissed as not worthy of their consideration. Two or three of the schemes presented a more than ordinarily favourable outlook. If any one of those schemes turned out successful for the company, it must, with its limited capital, prove of very great advantage to the shareholders. Up to the present, the company had not done any actual business, for they were in a quiescent position. The directors had been very economical in every respect, and had so dealt with the capital as to keep down the expenses in every way possible. In fact, he believed he might with confidence state, that that was one of the cheapest companies ever formed, and the expenses had been confined to a very small outlay, and the capital had been lent out upon good and approved securities in order to bring in interest, so that it should not be lying idle. Therefore, if they took away the amount of the preliminary expenses for the formation of the company, the interest which they were earning on the money paid their expenses, so that their capital was left intact. There was a great deal of business in front of them which might, or might not turn out to be for the benefit of the company. At any rate, the directors had very great hopes. The chairman concluded by giving some particulars as to the arrangements for office and other expenses with the view of keeping down the expenditure as much as possible.

Mr. E. Garckie (director) also corroborated the chairman as to the number of schemes which had been submitted for the consideration of the directors and added, that, of course, the future of the company depended almost entirely upon the development of the electric industries.

The Woodhouse and Rawson Electric Contract and Maintenance Company, Limited.—Creditors of the company are required, on or before the 11th day of October, 1890, to send their names and addresses, and the particulars of their debts or claims, and the names and addresses of their solicitors (if any), to Gustavus Adolphus Steinthal, of No. 41, Piccadilly, Bradford, in the county of York, the liquidator of the said company, or in default thereof they will be excluded from the benefit of any distribution made before such claims are received.

The Direct Spanish Telegraph Company, Limited.—The board has decided to recommend the payment of the dividend at the rate of 10 per cent. on the preference shares, and a dividend at the rate of 6 per cent. (free of income tax) upon the ordinary shares for half-year ended 30th June last.

TRAFFIC RECEIPTS.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending September 12th, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £5,666.

SHARE LIST OF ELECTRICAL COMPANIES.

Present Amount Issued.	Name.	Stock or Share.	Closing Quotation. (September 11.)	Closing Quotation. September 18).	Business done during week ending September 18, 1890. Highest.	Lowest.
£						
250,000	African Direct Telegraph, Ltd., 4 p. c. Deb. Regd. and to Bearer	100	98 —101	98 —101		
1,549,160	Anglo-American Telegraph, Limited	Stock	51½— 52¼	51½— 52½	51⅞	51
2,725,420	Do. do. 6 p. c. Preferred	Stock	88 — 87	88 — 89	88⅞	88
2,725,420	Do. do. Deferred	Stock	15¼— 16	15½— 15⅞	15⅞	...
130,000	Brazilian Submarine Telegraph, Limited	10	11⅜— 12¼	11⅜— 12¼	12 1/16	12
99,600	Do. do. 5 p. c. Bonds...	100	100 —102	100 —102		
75,000	Do. do. 5 p. c. 2nd Series, repayable June, 1906	100	103 —107	103 —107		
63,416	Brush Electric Engineering Ordinary, Nos. 1 to 63,416... ...	3	1½— 2	1½— 2		
63,416	Do. do. Preference, Nos. 1 to 63,416 ...	2	1⅝— 1¾xd	1⅝— 1¾xd		
$7,316,000	Commercial Cable, Capital Stock	$100	103 —105	103 —105		
224,850	Consolidated Telephone Construction and Maintenance, Ltd. ...	14/-	9/16— 11/16	9/16— 11/16		
20,000	Crompton & Co., Limited, 7 p. c. Pref. Shares, Nos. 1 to 20,000	Stock	5¼— 5¾	5¼— 5¾		
16,000	Cuba Telegraph, Limited	10	12½— 13	12½— 12⅝		
6,000	Do. do. 10 p. c. Preference	10	16½— 17½	17 — 18		
12,931	Direct Spanish Telegraph, Limited ... (£4 only paid)	5	3¾— 4¼	4 — 4½		
6,000	Do. do. 10 p. c. Preference	5	9 — 10	9 — 10		
60,710	Direct United States Cable, Limited, 1877	20	10⅜— 10⅝	10½— 10⅝	10⅝	10½
400,000	Eastern Telegraph, Limited, Nos. 1 to 400,000	10	13¾— 14¼	14 — 14½	14 3/16	13⅞
70,000	Do. 6 p. c. Preference	10	15 — 15½	15 — 15½	15½	...
200,000	Do. 5 p. c. Debs. (1879 issue), repay. Aug., 1899	100	106 —109	106 —109	108	
1,200,000	Do. 4 p. c. Mortgage Debenture Stock	Stock	105 —108	104 —107		
250,000	Eastern Extension, Australasia and China Telegraph, Limited	10	14 — 14¼	14½— 14⅝	14 5/16	14 1/16
320,000	Do. 6 p. c. Debentures, repay. February, 1891	100	100 —102	100 —102	100¼	...
446,100	Do. 5 p. c. (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. ...	100	103 —106	103 —106		
12,500	Do. 5 p. c. Debentures, 1890, redeem. ann. drawings ...	100	103 —106	103 —106		
367,900	Eastern and South African Tel., Ltd., 5 p. c. Mort. Deb., 1900...	100	102 —105	102 —105	102¾	...
45,000	Electric Construction, Limited, Nos. 101 to 45,100	10	7¾— 8¼	7¾—8¼		
19,900	*Electricity Supply Co. of Spain, Nos. 101 to 20,000	5	4¾— 5¼	4¾— 5¼		
46,700	Elmore's Patent Copper Depositing, Ltd., Nos. 23,001 to 70,000	2	7¾— 8¼	6¾— 7¼	8	6⅞
19,700	Fowler-Waring Cables, Nos. 301 to 20,000 ...(£3 only paid)	5	3 — 3½	2 — 2½		
180,227	Globe Telegraph and Trust, Limited	10	8¾— 9	8⅞— 9⅛	9 1/16	8 13/16
180,042	Do. do. 6 p. c. Preference	10	14¾— 15	14¾— 15	15	14
150,000	Great Northern Tel. Company of Copenhagen	10	15¾— 16¼	15¾— 16¼	15⅞	...
40,000	Do. do. 5 p. c. Debs. (issue of 1881) ...	100	100 —103	100 —103		
250,000	Do. do. do. (issue of 1883) ...	100	104 —107 xd	104 —107		
9,334	Greenwood and Batley, Ltd., Ordinary, Nos. 4,667 to 14,000 ...	10	11¼— 12½	11¼— 12½		
5,334	Do. 7 p. c. Cumulative Preference, Nos. 2,667 to 8,000	10	11¼— 12½	11¼— 12½		
41,600	India-Rubber, Gutta-Percha and Telegraph Works, Limited ...	10	18 — 19	18½— 19½	19½	19
200,000	Do. do. 4½ p. c. Deb., 1896...	100	102 —104	102 —104		
17,000	Indo-European Telegraph, Limited...	25	36 — 38	36 — 38	37½	36
38,348	London Platino-Brazilian Telegraph, Limited	10	6½— 7½	6¼— 7¼		
109,000	Do. do. do. 6 p. c. Debentures ...	100	105 —108 xd	105 —108		
49,900	*Metropolitan Electric Supply, Limited, Nos. 6,101 to 50,000 ...	10	4 — 4½	4 — 4½		
436,700	National Telephone, Limited, Nos. 1 to 436,700	5	4½— 4⅝	4⅝— 4⅞	4 13/16	4⅝
15,000	Do. 6 p. c. Cum. 1st Preference	10	12 — 12½	12 — 12½		
15,000	Do. 6 p. c. Cum. 2nd Preference (£8 only paid)	10	10 — 10½	10 — 10½	10½	10
220,000	Oriental Telephone, Ltd., Nos. 80,001 to 300,000 (11/- only paid)	1	⅛— ¼	⅛— ¼		
9,000	Reuter's, Limited	8	8 — 8½	8 — 8½	8⅝	8½
209,750	South of England Telephone, Ltd., Ordinary, Nos. 1 to 2,000, 2,501 to 3,500, 93,251 to 300,000	1	⅛— ¼	⅛— ¼		
20,000	Do. 6 p. c. Cum. Pref., Nos. 1 to 20,000 (£3½ only paid)	5	2¼— 3	2¼— 3		
3,381	Submarine Cables Trust	Cert.	113 —117	113 —117	117	...
78,949	Swan United Electric Light, Limited ... (£3½ only paid)	5	5 — 5½	5¼— 5¾	5 5/16	5¼
37,350	Telegraph Construction and Maintenance, Limited	12	42 — 44	42 — 44	43¼	43
150,000	Do. do. do. 5 p. c. Bonds, red. 1894	100	100 —102	100 —102		
55,000	United River Plate Telephone, Limited	5	3½— 4	3½— 4		
146,000	Do. do. 5 p. c. Debenture Stock... ...	Stock	90 — 94	90 — 94		
100,000	Do. do. 7 p. c. Debs., Nos. 1 to 1,000 ...	100	... ...	... ...		
15,609	West African Telegraph, Limited, Nos. 7,501 to 23,109	10	9 — 10	9 — 10		
300,000	Do. do. do. 5 p. c. Debentures	100	99 —102 xd	99 —102	100½	...
30,000	West Coast of America Telegraph, Limited	10	4½— 5	4½— 5	4½	...
150,000	Do. do. do. 8 p. c. Debs, repay. 1902 ...	100	101 —106	101 —106	104½	103½
64,572	Western and Brazilian Telegraph, Limited	15	11 — 11½	11 — 11½	11⅜	11
26,986	Do. do. do. 5 p. c. Cum. Preferred	7½	6¾— 7	6¾— 7¼	6 15/16	6 13/16
26,986	Do. do. do. 5 p. c. Deferred	7½	4½— 5	4½— 5	14 13/16	...
200,000	Do. do. do. 6 p. c. Debentures "A," 1910...	100	103 —106	103 —106		
250,000	Do. 6 p. c. Mort. Debs., series "B" of '80, red. Feb., 1910	100	101 —104	101 —104		
88,321	West India and Panama Telegraph, Limited	10	3 — 3½	3⅜— 3⅝	3⅝	3½
34,563	Do. do. do. 6 p. c. 1st Preference ...	10	11½— 12	11½— 12		
4,669	Do. do. do. 6 p. c. 2nd Preference ...	10	13½— 14	13½— 14		
1,336,000	Western Union of U.S. Tel., 7 p. c. 1st Mort (Building) Bonds	$1,000	120 —125	122 —127		
179,300	Do. do. 6 p. c. Sterling Bonds	100	97 — 99 xd	97 —99		
42,853	*Westmstr. Elec. Sup. Corp., Ord., Nos. 101 to 42,953 (£2 only paid)	5	1½— 1⅝	1½— 1⅝		

* Subject to Founders Shares.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

Blackpool Electric Tramway Company, Limited, £10 (£6½ paid), 7½—7⅝.—Elmore Copper Depositing Priorities, 7 —7¼.—Elmore Wire, ¼ dis—par.—House-to-House Company (£5 paid), 5 —5¼.—International Okonite, Ordinary of £10 (£7 paid), 6¾—7⅛ London Electric Supply Corporation, Ordinary (£5 paid), 2⅜—2½.—Manchester Edison and Swan Company, £9 (£1 paid) 11/- —13/-.

BANK RATE OF DISCOUNT.—4 per cent. (21st August, 1890).

WINE AND ELECTRICITY.

[FROM A CORRESPONDENT.]

IN an article of your issue for August 29th, headed "Electricity is Life," you spoke of its use for the improvement of spirituous liquors. This well-meant proposal has formed the subject of careful discussions in Hungary, rich as it is in wines, and it has even culminated in tangible proposals, though of very doubtful value.

Baron von ——, a writer on economical subjects, discussed this question at some length in a leader in the *Pester Lloyd*, a journal of a very wide circulation. He wrote:—"One of the most recent advances in the utilisation of electric energy is that of the electrolysis, or decomposition of liquids by means of the electric current. We can scarcely err if in this direction we entertain very bold expectations, and assume that new tracks of unexpected importance for practical life will be opened in this direction. Without doubt, agriculture and its connected arts will derive essential advantages from such inventions and discoveries. The electrolytic purification of sewage seems, as far as it can be ascertained, to be a matter of certainty, and justifies the most sanguine expectations. The question of the general de-fuselising of spirits by means of electrolysis is on the very point of solution, and the same is probably the case with the improvement of wine by the introduction of an electric current."

After a brief historical survey of the recent scientific investigations in this field, the writer of the article continues:—"For this new and promising process we are indebted to the American, Fraser. He takes a different method from that adopted by earlier experimentalists. Whilst they all conducted the current directly into the wine, and thus doubtless produced an effect which might be considered as too much of a good thing, Fraser only allows the electricity to act indirectly. He procured casks about 3 mètres in length and $\frac{1}{4}$th mètre in diameter, and were thus more like a wide pipe than a common cask. He covered the casks with coils of wire, just like the wrappings of an electro-magnet, and passed a strong electric current without interruption through the wires for 10 days. The casks were filled, some with different sorts of wine and others with freshly-distilled raw spirit. At the expiry of the 10 days, the casks had such a strong electric charge that, on touching them, strong electric shocks were experienced! The wine had deposited all its albumenoid matter and had assumed the colour and the bouquet of a fully-matured, ripened product, so as to be already in a merchantable condition. This electrised wine was further distinguished by its great permanence, as if it had been submitted to the Pasteur process. As for the brandy, it had likewise been advantageously modified by the electric treatment, and had acquired the flavour and the aroma of an old spirit many years in cask."

"In presence of such striking results, companies have been already formed in California for introducing the Fraser process on a large scale. It cannot be denied that the above experimental results may be of the greatest practical importance, both for producers of and dealers in wines and spirits. It is unnecessary for us to call the attention of our readers to the enormous pecuniary results which would accrue were it in the power of every dealer to transform his wines within a few days from a crude product to one fully matured and fit for bottling, and to give fresh brandy the flavour of an old product, rich in bouquet."

"Any one who feels an interest in this important question can make the experiment himself without much trouble or outlay. *He needs merely to take a few tall, slender casks and to wrap them round with a well insulated copper wire, in such a manner that between every two turns there is left a free interval of* 2 *to* 3 *centimetres in width.* A constant current is then passed through the wire for the requisite time, either from a secondary battery or from a dynamo. It is quite practicable to pass the current over from one cask to another, so that a single source of electricity will suffice for a number of casks."

If the reputation of the author did not guarantee the uprightness of his intentions, we might be tempted to view this article as a companion piece to the former farce of the electric sugar refinery. It is really inexplicable that chemical action can be produced by simply circulating a continuous current around a cask of wine! The writer, who is led to his project by the sincerest desire to relieve the wine industry of Hungary, hard pressed by the phylloxera has either not carefully read the descriptions of his authorities or has misunderstood them. In relating how the electric current is passed from cask to cask, forming, in a manner, central stations for refining wines, he forgets to say whether the casks are to be arranged in series or parallel. For persons who might be induced to try the experiment recommended in a paper of such eminence, it is fortunate that the electricity will in this manner have as little effect as the high tension currents have upon the phylloxera. I speak here merely of the experiments for the electric execution of this criminal which have been actually carried out, but have proved total failures. In like manner, the experiments in the *Pester Lloyd*, if useless, will do no harm.

ELECTRICITY AT THE AMERICAN ASSOCIATION.*

By Prof. H. S. CARHART.

THE address of Prof. Cleveland Abbe, vice-president of the Physics section of the American Association for the Advancement of Science, at the recent Indianapolis meeting, was on Terrestrial Physics. It touched upon the obscure question of the origin of terrestrial magnetism. Prof. Abbe concludes from the low permeability of iron at high temperatures that the metallic portions of the earth interior cannot be magnetised, and that terrestrial magnetisation must be restricted to the earth's shell or crust. He therefore inclines to the theory of magnetism derived from terrestrial currents in planes at right angles to the axis of rotation. He reasons that the earth is immersed in a dielectric, and is placed in some kind of electrical field due to solar radiation. If this were the case it would require no inconsiderable currents round the globe as a solenoid to produce the known terrestrial magnetism, since the cause operating to prevent permanent magnetism in the earth's interior would also prevent such material from serving as the core of an electro-magnet.

In the physical section Prof. Mendenhall presented facts, derived from the magnetic observations of the Coast and Geodetic Survey, going to show that magnetographs often record earthquake disturbances, not as mechanical shocks, but as magnetic perturbations. These he conceives to be due to the sudden stresses to which the earth is subjected in earthquakes; and these stresses modify the earth's magnetism. In support of this view he showed, from an analysis of the photographic records of magnetographs, that two diurnal fluctations in declination depend upon lunar action; and he ascribes these to the stresses in the earth's crust produced by the same forces which raise the tides. The subject will be pursued further by observers of the Geodetic Survey.

Prof. Nipher, of St. Louis, described a new method of measuring the electrical resistance of liquids, such as the internal resistance of a battery. It consists briefly in placing the resistance to be measured in one arm of a bridge with a two-part commutator to effect rapid reversals of the current through the electrolyte. From measurements thus far made the results are found to agree with those of approved methods to within 1 per cent.

Mr. E. G. Merritt described the peculiar behaviour of a galvanometer when used with a thermopile. It consists in small periodic pauses in the deflection of the needle when the thermopile is exposed to a steady source of heat radiation.

These pauses, which may even amount to reversals in the motion of the needle, for a short distance, are always equi-distant in time; and the first maximum bears a definite ratio to the total deflection which the needle will reach if the radiation upon the face of the pile be continued indefinitely. Comparisons of different sources of radiant heat may, therefore, be made by observations of the first maxima occurring at the first pauses of the needle. The phenomenon was shown to be due to the composition of a damped vibration of the needle, and a deflection produced by an E.M.F., the law of variation of which may be expressed by an exponential curve. The paper was an admirable example of a short investigation completely worked out.

* *Electrical Engineer*, of New York.

Sections A, B, C, and D of the Association spent one day by invitation at Terre Haute, and held sessions in the Rose Polytechnic Institute. An elegant dinner was served at the Terre Haute House to the 200 guests, and Colonel R. W. Thompson, ex-Secretary of the Navy, made the address of welcome. Colonel Thompson welcomed the Association to the same place 19 years ago. He excited lively interest by his vivid narrative of experience with Morse, and of his efforts to secure a $25,000 appropriation from Congress to construct an experimental telegraph line. In this connection he said that one of his colleagues was subsequently defeated for Congress because his constituents disapproved of his vote for the appropriation for the telegraph. What a commentary on the righteous judgment of the people!

Many members took occasion during the meeting to ride on the electric railway in Indianapolis. It works admirably; and the central line of iron poles, carrying the wires, is an ornament to the street rather than a disfigurement. A large party accepted the kind invitation of the Parry Manufacturing Company to visit their factory for the purpose of witnessing electric welding on a commercial scale. They saw a single workman welding wagon tires at the rate of about three per minute. Two men were engaged in welding inch axles also, and both operations were conducted with the most gratifying success. The process is very satisfactory to the manufacturers, and its rapid introduction into large plants is assured.

The papers presented to the physics sections of the Association included a relatively smaller number on electrical topics this year than for several meetings. Other departments of physics received a larger share of attention than usual. The papers were of a high average, but none reached the highest water mark.

ELECTRICAL CENSUS TAKING.

THE chiefs of the Population Division of the United States Census Office celebrated the completion of the count of the population of the United States by a dinner at "Glen Echo" recently. The "Hollerith electric tabulating system" has been in use by the Census Office for the tabulation of the schedules of the population taken under the eleventh census. Superintendent Porter in expressing his congratulations upon the rapid and accurate completion of this great work, spoke as follows:—

It may not have occurred to any of this little band of faithful workers, consisting of chiefs and section chiefs from the Population Division of the Census, that you are celebrating a great event here in this picturesque spot. For the first time in the history of the world the count of the population of a great nation has been made by the aid of electricity. The number of names on every one of 15,000,000 schedules has been registered twice by the nimble and expert fingers of the counters, and the 64,000,000 people have marched, as it were, under the vision of the young men and women who have done such remarkable work with such extraordinary rapidity and precision. What a procession you have had pass before you. The men who wrote those names have had to find them in every human habitation, and existing under every imaginable condition within this vast domain of ours. In June these blanks were distributed throughout the country. In July and August they find themselves back in the Census Office, counted twice and ready for the next statistical treatment. Allowing for the time spent in teaching and in fitting up the machines, the count proper was not commenced before July 1st, and the night force was not organised until some time afterwards. We have actually counted 128,000,000 in six weeks, or the entire population of 64,000,000 twice in that period. Beginning with 2,000 and 3,000 families, or 10,000 and 15,000 persons per day, the operatives progressed in dexterity, until last Thursday no less than 43 counted over 10,000 families or 50,000 persons each, one young lady reaching the astonishing total of 16,071 families or about 80,000 persons. On that day not only the highest averages were reached, but the greatest number counted, the report showing 1,342,318 families or 6,711,590 persons. This represents an average of 8,135 families or 40,675 persons per clerk. In this connection I think it my duty to say that in the "general average" the male clerks, man like, I hear some of the young women whisper, seek refuge behind the petticoats of the gentler sex. The average number counted by the women clerks was 9,590 families, or 47,950 persons, and by men clerks, 6,587 families or 32,935 persons. Thus it will be seen that the women average nearly one-half more than the men. It is also worth noting that of the 43 who counted more than 10,000, 38 were women and only five men. These facts, and indeed the record of the entire six weeks, show that women are better adapted for this particular work than men. They are more exact in touch, more expeditious in handling the schedules, more at home in adjusting the delicate mechanism of the machine, and apparently more ambitious to make a good record.

While I congratulate you on the completion of the rough count, and thank you sincerely for the great interest you have taken in this work, for the many extra hours you have freely given to keep it moving, I must sympathise with you in the sorrowful fact that you have no more countries to count. Alexander is said to have wept because he had no more worlds to conquer, and Hunt and Sutherland in the midst of this gay festivity look solemn and sad at the paltry total of 128,000,000, and, with a ghastly smile, I can hear them say: "We had to count the population twice in order to reach those figures." Distance is overcome and lessened when we can flash our thoughts thousands of miles in a few minutes, and cross the Atlantic in five days. So it is in census work. With the force that left work this afternoon, working night and day as we have worked, we could, with these electrical machines, count the entire population of the United States in ten days of seven working hours each.

Estimating the population of the civilised world at 650,000,000, we could count it in 100 days; while the bright young women and sturdy young men of our population division could run through the entire population of the earth, which, including Asiatics and savages, is estimated at 1,300,000,000, in less than 200 days, providing places could be found to store the schedules. And while we thus glorify our own little achievement, we must not forget that we have here with us the modest man who invented the wonderful machine with which we have accomplished such magical results.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.—LEEDS, 1890.

RECENT DETERMINATIONS OF THE ABSOLUTE RESISTANCE OF MERCURY.

By R. T. GLAZEBROOK, F.R.S.

(Printed from Notes used for the discussion on Electrical Units in Section A of the British Association, Leeds, September 10th, 1890.)

WE are here to-day to discuss some of the determinations of the value of the ohm when expressed as the resistance of a column of mercury, with a view to seeing if any action is practicable by which the standards in general use may be brought nearer to their theoretical value than they are at present. The time is opportune, for we have the advantage of having in Leeds Prof. Mascart, of Paris, and Prof. Rowland, of Baltimore, under whose directions some of the most important of the investigations we are to consider to-day have been made, and Prof. Barker, one of the American representatives at the Paris Congress. Moreover, it seems probable that a Congress will again meet shortly to consider this question, and a preliminary discussion here may be of value in clearing the ground.

The question at issue is whether the results of experiment are sufficiently in accord with each other to render it probable that any number adopted by us would be generally accepted, and, if so, to determine what that number is.

The problem has two sides. The resistance of a wire is expressed by means of one series of experiments in terms of a length and a time, while by another series of experiments it is expressed in terms of the resistance of mercury, and thus the resistance of mercury is found absolutely. Frequently, however, there is an intermediate step; the resistance of the wire is expressed in terms of some standard resistance, and this standard is expressed in terms of mercury.

The methods employed to compare a standard resistance with that of mercury are all very similar in their nature, and the experiment is not one of very great difficulty. Accordingly we find that the results of the experiments are fairly concordant.

In Table I., column 5 gives the values found in B.A. units for the resistance of a column of mercury 1 metre long, 1 square mm. in section at 0° C.—a Siemens unit, as it is called. The values found by Lord Rayleigh and M. Mascart are higher than later ones. A comparison of the values found for the B.A.U. in ohms and for the Siemens unit in B.A.U. by M. Mascart, leads to the conclusion that possibly his B.A.U. had changed a little between the time at which it was compared with the standards at Cambridge and the time at which it was used. As to Lord Rayleigh's value, the fact that the coil F was his principal standard, and the coil F has certainly changed relatively to the other coils in the last two years, may help to explain the difficulty, but it must be remembered that F had the same value relatively to the others in 1888 as it had in 1881, when examined by Dr. Fleming.

The other numbers are in close accord, except one result of Salvioni's, which must, I think, be capable of a simple explanation. Strecker, Kohlrausch, and Salvioni differ somewhat from Wilkes and myself; in consequence, I believe, of the fact that they worked at the temperature of the room, while Wilkes and I worked at the temperature of melting ice. A small change in the temperature coefficient used by them would easily account for the difference.

Wuilleumeier's mercury coils were the same as those employed by Mascart, Benoit, and de Nerville. We may thus take ·9535 B.A.U. as being very accurately the resistance of a column of mercury 100 cm. long 1 square mm. in section.

But when we inquire what are the results which have been obtained for the value, in ohms, of the B.A.U., or of the mercury unit, the discrepancies are considerable.

Let us consider the methods. An admirable summary of these will be found in Wiedemann's *Electricitat*, vol. iv., p. 910, or in Mascart and Joubert's *Leçons sur l'Electricité*, ii., pp. 581, *et seq.* They have also been critically discussed by Wiedemann and by Lord Rayleigh in the *Phil. Mag*, vol. xiv., 1882. We will take them in order.

VALUE OF OHM EXPRESSED AS THE RESISTANCE OF A COLUMN OF MERCURY.

	Observer.	Date.	Method.	Value of B.A.U. in ohms.	Value of 100 centimetres of mercury in B.A.U.	Value of ohm in centimetres of mercury.
1	Lord Rayleigh	1882	Rotating Coil	·98651	·95412	106·24
2	Lord Rayleigh	1883	Lorenz method	·98677	—	106·21
3	G. Wiedemann	1884	Rotation through 180deg.	—	—	106·19
4	Mascart	1884	Induced current	·98611	·95374	106·33
5	Rowland	1887	Mean of several methods	·98644	·95349	106·32
6	Kohlrausch	1887	Damping of magnets	·98660	·95338	106·32
7	Glazebrook	1882 and 88	Induced Currents	·98665	·95352	106·29
8	Wuilleumeier	1890		·98686	·95355	106·27
		Mean		·98656	—	—
9	Strecker	1885	An absolute determination of resistance was not made. The value ·98656 has been used		·95334	106·32
10	Hutchinson	1888			·95352	106·30
11	Salvioni	1890			·95332 or ·95404	106·33
12						
	Mean without 12				·95355	106·28

	Observer.	Date.	Method.	Value of B.A.U. in ohms.	Value of 100 centimetres of mercury in B.A.U.	Value of ohm in centimetres of mercury.
13	H. F. Weber	1884	Induced current	Absolute measurements compared with German silver wire coils issued by Siemens or Strecker		105·37
14	H. F. Weber	—	Rotating coil			106·16
15	Roiti	1884	Mean effect of induced curr.			105·89
16	Himstedt	1885				105·98
17	Dorn	1889	Damping of a magnet			106·24
18	Wild	1883	" "			106·03
19	Lorenz	1885	Lorenz method			105·93

I.—*Kirchoff's Method.*

This has been used by H. F. Weber, Rowland, Mascart, and Glazebrook. The formula may be written—

$$R = \frac{4\pi M}{T} \cdot k \cdot \frac{\alpha}{\beta}.$$

Where M is the coefficient of induction between the coils, T the time of swing of the galvanometer needle, α the deflection due to primary current, β the throw due to the induced current, and k a ratio either of two galvanometer constants or of two resistances; all small corrections are omitted.

The main difficulty is in calculating the value of M, which depends approximately on a^2/b if a is the radius of either coil, and b the distance between the coils.

In the coils used by myself the value of a was about 26 cm.; that of b varied from 12 to 24 cm. An error of ·1 mm. in b produces an error in the result between 1 in 1,500 and 1 in 2,000. In one position of the coils, the correction arising from the fact that the cross-section of the channel was of finite area was less than 1 in 1,000. There should, it seems to me, be no difficulty in finding M to the one or two in 10,000. The coils used by Rowland and Weber in their earlier experiments, and by Mascart, were smaller. In his last experiment in 1883 Weber used coils of 32 cm. radius. In their later experiments Rowland and Kimball had large coils, about 50 cm. in radius.

The various results are:

H. F. Weber	105·37
Rowland	106·29
Mascart	106·33
Glazebrook	106·29

It will be noticed that all H. F. Weber's results are very low. He used as his standard wire a 10-Siemens unit taken from a resistance-box, not a coil which had been compared directly with mercury, and it seems possible that a common error in this affects all his results; he also used large magnets. The other values are in fair agreement, though we may probably agree with Lord Rayleigh in thinking that the limit of accuracy of the method has not been reached.

II.—*Weber's Method.*

The approximate formula again is

$$R = \frac{2\pi G g}{T\beta} = \frac{4\pi^2 N N'}{T\beta} \cdot \frac{a^2}{A},$$

where G is the constant of the galvonometer, g the area of the earth inductor, and in the second expression, a is the radius of the inductor, A, of the galvanometer, N and N′ being the number of turns on either.

This method was followed by Mascart, who used with a coil of 15 cm. diameter and a galvanometer the constant for which was compared with one of known constant—viz., the inductor. The time taken to turn the inductor was one-fifth of the time of vibration of the galvanometer needle. There is the difficulty of making the axis vertical and the effect of the time of duration of the current on the throw of the galvanometer to consider. My experiments show that if the effect of the induction current be prolonged for a period of one second, the time of swing being 23 seconds, then the deflections are reduced by ·1 per cent. With the circuit open for two seconds the effects are marked.

The same method has been used by G. Wiedemann, who is inclined to think it the best. He employed coils of W. Weber and Zollner, one metre in diameter, which were wound and measured twice. He calculated G using as galvanometer coil a counter-part of the inductor; the effect of the current was determined by measuring effects of a series of impulses at proper moments. The time of turning the inductor was two seconds, while the period of the needle was one minute. This would tend to reduce β, this to increase R, and hence to decrease the length of the column, which was found by comparison with a Siemens unit; the same unit was compared with mercury.

Mascart thinks the difficulties of this method inspire with doubt the results thus obtained. Experiments near the magnetic equator would, Lord Rayleigh points out, decrease the effect of level error. Wiedemann thinks this method is to be recommended for final determinations. Rowland criticises the method.

The results obtained are:

Mascart	106·37
Wiedemann	106·19

III.—*Method of British Association Committee.*

$$R = \pi^2 N^2 a \Omega \cot. \phi$$

The only measurement, apart from corrections, is that of mean radius. The corrections, however, are important, for the self-induction of the rotating coil requires to be known, while the magnetic field in which the coil is moving is modified by the presence of the magnet at its centre, so that the magnetic moment of this magnet has to be determined. In order to reduce the amount of this correction, this magnetic moment is made small, and this again leads to difficulties.

The following difficulties are urged by Wiedemann:

(1) Correction due to self-induction. (2) Difficulty of levelling. (3) Want of steadiness from draughts, etc. (4) Small magnetic moment.

In reply, we may say that

(1) Can be corrected for.

(2) Level error common to several methods (see II. above).

(3) Effect can be eliminated by experiments with open circuit.

(4) Theory of the correction is very simple; a knowledge of M/H only is required.

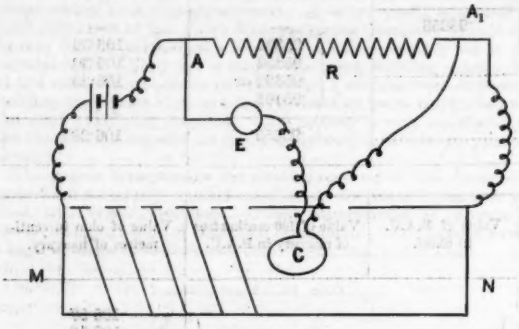
The method was used by Lord Rayleigh, leading to the result, 106·24. It was also employed by H. F. Weber, who used rotation about a horizontal diameter in the magnetic meridian to avoid the correction depending on M/H.

IV.—*Foster and Lippmann.*

$$R = 2\pi^2 \Omega \frac{a^2}{A} \cot. \varphi N N'$$

A rotating coil is used, but contact is made only at the moment when E.M.F. is a maximum, and E.M.F. is balanced by that due to an

external current through a known resistance. Observations have been recently carried out by Wuilleumeier by this method with modifications. He used the induction from a long spiral, MN (see figure), 2 metres long 30 cm. diameter, placed east and west, wound with one layer of wire 2 mm. in diameter. A coil, C, wound on a disc of hard wood, 20 cm. in diameter, rotates in this, and the circuit is closed when the E.M.F. in this a maximum; the E.M.F. thus produced is balanced against that produced in the current in the spiral when flowing through a resistance, R, the action of the earth's magnetism being compensated. One point, A, of R, is in connection with the coil through E, the other end is straight, and a movable contact is established at A_1 A etc. Corrections for its ends are obtained by shifting the spiral coil. The resistance of R was about ·3 ohm, made from a strip of German silver of rectangular section 34·72 metres long, 1 cm. broad, ·3 cm. thick, immersed in naphtha.



The primary current was 12 amperes. A Lippmann electrometer was used. The E.M.F. was nearly four volts. The diameter of the rotating bobbin was 20 cm. Hence, error of ·1 mm. in mean radius makes error of 1 in 1,000. The formula assumes spiral to be uniformly wound. Result is 106·267.

V. *Method of damping.*

Set a magnet in a coil. The motion of the magnet sets up currents, which react on the magnet and damp it. A relation can be found between these currents, and the rate of damping. To a first approximation it is

$$R = \frac{\pi}{2}\frac{1}{T}G^2\frac{M}{H}\frac{(\pi^2+\lambda^2)}{\lambda-\lambda_0}$$

λ, λ_0 being logarithmic decrements.

G has to be compared with the constant of another coil, because of the size of the coil. Let k be the ratio—

$$R = \frac{2\pi^3}{T}\frac{N^2k^2}{A^2}\frac{\pi^2+\lambda^2}{\lambda-\lambda_0}r^2\tan\alpha.$$

Where A is the radius of standard coil, N the number of its turns, α the deflection which the magnet produces in Gauss's first position when at a distance, r.

Further corrections are required for length of magnet, and for the uncertainty as to the distribution of its magnetism and for self-induction.

In the opinion of Lord Rayleigh and Rowland, the final formula is enough to show that the method cannot compete with the others. Other difficulties are that calculation assumes the arc of oscillation is small, G is not independent of the displacement.

Currents are set up in the magnet, which affect its motion. A correction is required for temporary induced magnetisation due to action of current, this may be appreciable. In general there are difficulties in applying the theory.

The method was used by H. F. Weber. His magnet was 8 cm. long, his coil 16 cm. in radius; G was calculated, a uniform distribution of magnetism being assumed.

Dorn introduced corrections to the theory; he found G by comparison with a large coil, compared result with a Siemens unit, verified by Strecker; his magnet was 17 cm. long, closely surrounded by the coil. Wild suspended the magnet bifilarly; it was 29 cm. long, and the coil closely surrounded it; a resistance-box was used.

Kohlrausch's magnet was 20 cm. long, with brass ends. The coil was close to it, G was compared with that of a large galvanometer. Resistance compared directly with a tube calibrated by Strecker.

The results are:

H. F. Weber	104·77
Dorn	106·24
Wild	106·03
Kohlrausch	106·32

VI.—*Lorenz Method.*

$$R = n\,M.$$

The main difficulty lies in the calculation of M. This is more easy than in I, for the disc can readily be measured.

In Lord Rayleigh's apparatus an error in the radius of the coil does not greatly affect result. Further increase of size possible and desirable. The smallness of the effect, and therefore of R is not fatal. See Lord Rayleigh's observations.

Thermo-electric effects can be compensated for.

Results:

Rayleigh	106·24
Rowland	106·29
Lorenz	106·19

Lorenz value is too low because of the size, of the mercury tubes used by him.

VII.—*Roiti and Himstedt.*

$$R = n\,M\frac{\alpha}{\beta} = n\,4\pi^2a^2\,\frac{N\,N_1}{1}\,\frac{a}{\beta}.$$

There is a difficulty in having many contacts, for if the contact does not last all the time supposed, β would be too small, R too large, and the length of column too short. There is also an important correction for the ends, and the assumption is made that the coils are uniformly wound. Another difficulty is the theory of the galvanometer under such discharges.

The resistances were compared with a Siemens unit, and in the case of Roiti with one of Strecker's coils.

The results are:

Rioti	105·89
Himstedt	105·98

VIII.—*Calometric Methods.*

The results by these methods cannot claim any great accuracy.

Having thus completed the review of the methods, we must look at the results; and after what I have said, we may, I think, reject all work previous to 1882.

The results of H. F. Weber are manifestly too low, while serious doubts attach to the methods of Roiti and Himstedt. For Weber's first method, the early results of W. Weber and Zollner may be omitted compared with those of G. Wiedemann, while the results given by the method of damping will be sufficiently represented by the work of F. Kohlrausch, who alone of those who used this method compared his results with the resistance of mercury directly.

The experiments of Lorenz will not, I think, stand rigid criticism, while, unless I am much mistaken, Lenz, who also used Lorenz' method, has only published results and not details.

We are thus left with the following list, including the results only of those who have made both the mercury and the absolute determinations:—

Lord Rayleigh	106·23
Mascart	106·33
G. Wiedemann	106·19
Rowland	106·32
Kohlrausch	106·32
Glazebrook	106.29
Wuilleumeier	106·27
Mean	106·28

If we take in Lord Rayleigh's results for the value of the B.A.U. in ohms, for 100 cm. of mercury in B.A.U. the value ·9535 instead of ·9541 given by his own experiments, we get, instead of the values 106·21 and 106·24 the values 106·27 and 106·30. The mean, then, of the whole would be 106·29. If we include the three numbers (9, 10, 11) of the table, we get the value 106·30.

It seems, then, to me, that the number 106·30 certainly expresses the true value within one or two in 10,000, and that the time has come for carrying the conclusions of the Paris Congress one place further.

The establishment of the new standardising laboratory calls for some authoritative expression of opinion here in England. Are we prepared to express our opinion?

In 1886, the Standards Committee agreed, on the motion of Sir W. Thomson, (1) to recommend for adoption for a term of ten years the legal ohm of the Paris Congress as a legalised standard sufficiently near to the absolute ohm for commercial purposes, and (2) that at the end of ten years, the legal ohm should be defined to a closer approximation to the absolute ohm.

The Government took no action on this matter, and the opportunity is afforded us of revising, not in ten years, but in four, our provisional suggestion. Shall we replace the 106 cm. by 106·30 cm.

For my part I should be guided greatly by the amount of acceptance that such a decision would meet with. If Prof. Rowland and Prof. Barker, who was with us in 1886, can tell us that they would agree in recommending the Government of the United States to adopt the same view, and if Prof. Mascart thinks that such a course would meet with the approval of himself and his distinguished colleagues in France, I should be heartily glad of it.

If, on the other hand, they press for further time in order that experiments of a higher degree of accuracy, which can no doubt be attained, though probably at great cost, may be carried out, I should deprecate the Committee coming to any conclusion which might pledge them to a number which does not meet with general acceptance.

Discussion.

Prof. Rowland (America) said, as one of the members of the United States commission for the determination of the ohm, the matter in America was entrusted to me. The commission consisted of Profs. Barker, Trowbridge, and myself. The experiments were carried on at the John Hopkins University, under my superintendence, with considerable appropriation from the United States Government. The experiments have been going on for many years, and we have continued to experiment down to the present time, and, indeed, the whole matter has been gone over by one of my associates, Dr. Duncan, Professor of Applied Electricity

and he, with his students, has determined not only the absolute unit, but also has made a complete determination of the mercury unit. Unfortunately, I cannot bring figures, as I have been travelling for several months, but they have been gone into, as I said, very carefully, and, if I recollect rightly, the number, 106·32, has been slightly diminished. Mr. Glazebrook's criticism, however, has been so exhaustive that I can add very little with respect to it. As to which are the best methods, there are very few who will dispute that the method of Lorenz is the best for this determination. You have a very definite quantity to measure—the diameter of a revolving disc, which is a very definite quantity—and then, as Lord Rayleigh has shown, the determination can be made, so as to almost entirely eliminate the radius effects of the coil, that is the most important feature of the experiment, because nothing is undetermined in the experiment, such as the radius of the coil of wire. You wind the coil in the groove, but as to where the different wires are in the groove it is impossible to determine with any very great accuracy; so, if we can eliminate this quantity, we can get more accurate results. Therefore, all experiments which depend on the square of this quantity, as, for instance, when you have revolving coil, I think all have this source of error. I think the Commission of the United States would be perfectly willing to recommend the figures, so far determined. Those who were connected with the commission will recollect that the United States never recommended to the Government any figures whatever. The 106 decided on by the Paris Conference was never accepted by the United States, even provisionally, and therefore the matter has been left entirely open to the present time, because we felt that you in England would come to some figures of this sort. We are now prepared in America to recommend some figure based on the result here given, and I may mention that the Superintendent of the Coast Survey has intimated to the committee that they are willing to establish a bureau of electrical measurement, under the charge of the United States Coast Survey. I do not suppose they will take up many units, but at least they will take up the unit of resistance, if they have the sanction of the United States Government.

Lord RAYLEIGH said that it made him feel very antiquated to see his name at the head of the list of 18 determinations of the ohm. He thought Mr. Glazebrook was quite right to begin where he did, because before 1882 the results obtained were comparatively wide. At that time discrepancies of 3 per cent. existed. It was very satisfactory to find that now the whole question was narrowed to one in a thousand instead of three in a hundred. Certainly, looking at those figures, and listening to Mr. Glazebrook's able exposition of the methods followed by various observers, it looked very much as if the number obtained by himself for the specific resistance of mercury were a little in error. That number, ·9541, was higher than those found by recent experiments. The only difficulty he found in accepting that view was that he found the observation exceedingly easy to make, and probably, for that reason, he was wrong. But still, he was not content with an agreement between the first two or three measurements. The experiments were protracted for a considerable time, and considerable variation was used in preparing tubes, and the degrees of concordance in the results was very great. Certainly, at the time, he would have thought it extremely unlikely that any repetition could have altered the figures ·9541 into ·9535, or whatever was thought most probable. At the same time, anybody who had had any experience of that kind of work must know that unexpected errors did creep in. Since the publication of Mr. Glazebrook's paper upon the subject, in which to a great extent the same method, and even the same apparatus, was used as that which he (Lord Rayleigh) employed, he had gone into the matter very carefully, in the hope of, perhaps, finding where the difference lay between them. But he had been unable to find any error in the work which led him to the higher number. The notes of the experiments were nearly complete, and it was as easy to make the calculations now as at the time of the experiments. He could not explain the discrepancy, unless there had been a shifting in the standard coils themselves, in comparison with which the mercury tubes were observed. Mr. Glazebrook had shown that if they discarded that number (·9541) and substituted for it the recent comparisons of mercury with the B.A. unit, then the absolute numbers that he (Lord Rayleigh) obtained for one B.A. unit would lead to very nearly the same results for the length of the mercury column as had been obtained by others. It looked as if the general balance of evidence was in favour of 106·30, which Mr. Glazebrook had taken, although he might be sanguine in supposing that we are confident of it to two parts in 10,000. He was in commenting upon Lorenz's work, to say that he had not taken not quite sure whether he had rightly understood Mr. Glazebrook, account of the manner in which a current would enter a wide column of mercury from a wire. It was a good many years since he had taken this into account. He had a distinct impression of functions which would represent the manner of divergence. At any rate, he must have been quite on his guard in that matter. He (Lord Rayleigh) was sometimes inclined to think that a little too much importance was attached to the expression of the resistance of mercury absolutely. Supposing that they could be quite sure the length of the column of mercury was 106·30, what use were they to make of the fact? An electrician, in his laboratory, did not find it easy to set up a mercury tube, and to obtain results by that method. In a factory, it would be still more unlikely that mercury would be employed for the purpose. Practically, to make use of the determination, they must have a wire. He was inclined to think the numbers expressing the B.A. unit were quite as important as those into which mercury entered. Mr. Glazebrook had explained that a wire was first expressed in absolute measure, and then the comparison was made with mercury. It was very important, no doubt, to make that comparison for standard wires, but it was really the wire that was wanted for practical purposes, and therefore he thought as much importance should be attached to the fifth column of figures as to the last. The only other thing that occurred to him to say was that he did not quite understand why so very much less importance is attached to the determination of the ampère as to the determination of the ohm. They had there a long series of determinations on the subject of the ohm. So far as he knew the received ampère depended upon only two sets of observations, those of Prof. Kohlrausch and himself. It was true that it was more difficult to define the ampère than the ohm, but it was as important that it should be defined; and he would suggest to those who still felt inclined to experiment on the subject of electrical units, to repeat the measurement of the ampère, feeling that that is perhaps liable to greater uncertainty than attached to the ohm.

Prof. BARKER (America), expressed great gratification at the reception they had met with. He had been struck with the clearness and justness of the statements of Mr. Glazebrook in regard to the matter. It had been placed before them in such a manner that the thanks of the section were due to him. He felt that they in America occupied an anomalous position in regard to the ohm. When the Congress of 1881 determined to submit to experimental determination in the various countries, the work was undertaken on behalf of the United States by their committee under the presidency of Prof. Rowland. The work occupied some time, and was made with a great deal of care, in consequence it was not completed when the meeting of 1884 took place. They (the committee) petitioned for a further postponement, in order to enable the results of the American experiments to be presented at the Paris Congress. This, however, was not done. As they all knew, action was taken in Paris upon results which did not include the American observations. Having no part in it, therefore, they should be considered to be entirely independent as to whether 106, which is dignified by the name of the legal ohm, although it has never been legalised in England or America, should be still further legalised by England or the United States, or whether what seemed positive knowledge now should not be legalised. As Mr. Glazebrook said, it was fortunate that the English Government took no action in regard to the matter. He (the speaker) attended the meetings of the committee, and he supposed the pressure of having some legalised standard led to the suggestion of Sir William Thomson that 106 should be adopted. At that time probably that figure came up to their knowledge, but now was an opportune time to take legal action. He seconded Prof. Rowland's opinion that the United States would be very glad to adopt 106·3, which the committee of the B.A. recommended for adoption as the ohm. It would be also great satisfaction if Prof. Mascart would secure similar simultaneous action in France in the same direction. They in America were very much indebted to Englishmen for the work accomplished here, more especially to the various committees of the B.A. He might be allowed to refer to another matter, scarcely germane to the subject under discussion. It would be remembered that at the Paris Exhibition of 1881 the name of Weber was taken away from unit of current, and the name of Ampère substituted, and the name of Coulomb for quantity. At that time, he (the speaker) suggested that the Americans were entitled to some sort of representation, and he suggested the name of Franklin for one of the units, which was seconded by Prof. Mascart. This, however, was not done, and he wished to say that they would support England in the matter of the units, if it would support them in getting in the name of Franklin somewhere.

Sir WILLIAM THOMSON said he was afraid he might be held to be a partisan of 106. He begged to say that he was not, and never was. He thought Mr. Preece would bear him out in that. They fought hard for 106·25 at the Paris Congress, but the case turned out for 106 or nothing; and for the whole German scientists and instrument makers to be left to the Siemens unit. The two brothers Siemens, Werner and William, were present, and they very much desired that a mercury unit should be kept, recommending and suggesting very good reasons for keeping it, reasons to which Lord Rayleigh alluded, and which they still considered of great importance. The mercury unit then was adopted, and the question was how many centimetres, instead of the Siemens 100, was to be taken for the new unit. Now, it so happened that there were no observers present (and there were a considerable number of distinguished men present from Germany and Italy), but no observers whose results went above 106; the average of all the results before the Congress came to almost exactly 106. He urged that Lord Rayleigh's were worth all the others put together, and he believed that he persuaded the mass of the Congress to that fact, but he could not bring them to the point of voting. When four years ago he proposed the ten years period, and that was carried by the B.A., electricians did not live so fast as they did now, and he was only too glad to see that four years had done the work of ten, and he cordially agreed with Mr. Glazebrook, Prof. Barker, and Prof. Rowland in feeling very thankful indeed that the British Government did not take any action on the resolution of the B.A. committee adopted four years ago. He cordially agreed in the idea held now by persons present and many who were absent that now had come the time for fixing the standard at 106·3. He thought that nearer than 106·4. The results were certainly much more than 106·2, and less than 106·4. 106·3 was the nearest whole

number, it was much better than 106. It was within 1 or 2 parts in 10,000 of the true value. One word about the B.A. method. He did not know that there would be any proposal to go on with any more elaborate methods, but if any more great experiments were to be made, he would just say a word for the B.A. method that they had not yet seen all that it could do. He spoke of that very question with Clerk-Maxwell, about levelling and sensibility, and it was obvious that the right place to do the experiment was the equator, and Clerk-Maxwell was ready to go there to do it; and he (Sir William Thomson) believed that if he had been spared he would have kept that in view. Going to the equator would at once increase the sensibility in the ratio of the horizontal force at the equator to the horizontal force in England. It would absolutely do away with all trouble in respect of level. He hoped, if any more observations were made, the B.A. method would be kept in view with that fact, that results at the equator would be more accurate than it was possible to get with observations made in Leeds or at Cambridge, where they had been made. He called attention to the remarkable agreement now between the results of several observations obtained with such very different methods. It was quite surprising to find all come so close to that 106·3, when they considered the great difference between the methods.

Mr. PREECE said he thought to a certain extent he must accept the responsibility of having advised Her Majesty's Government to decline to accept the 106 as the legal unit in 1886, and the reasons for that course were very powerful and very numerous. Any change that would have then been made would have meant most serious expenditure. The number of apparatus adjusted to the B.A. unit, not only in this country but in the colonies and all over the world, was so enormous that any change made would have been a matter involving one costing many thousand pounds, and one that would certainly result in another change within ten years. There is no doubt it would have been wrong then; on the other hand, there is equally no doubt that at the present time we shall be perfectly right in making a change. After hearing what has been said on the subject, he would not have the slightest hesitation in recommending 106·3 to the Institution with which he was connected as representing the true ohm. They must remember that although it might not be absolutely accurate, it was as accurate as most measuring instruments, in some cases far superior. In reply to Lord Rayleigh's question why we did not measure the ampère, the measurement depended not only on the accuracy of the ohm, but also on an accurate knowledge of the measurement of the volt, and when they had the volt represented as accurately as the ohm, then, perhaps, they might fall back upon the ampère. At the moment, the only measurement of the unit, E.M.F., was the measurement made by Lord Rayleigh himself, and he did not think that as accurate as the mean results brought before them that day. Although the discussion before them took in view general electrical units, he did not wish to raise any question except on that of the ohm, still he wanted gentlemen present and electricians to take into consideration at some future day the entire alteration of the volt. It was a most unfortunate thing that the volt was taken as equivalent to 10^8 C.G.S. units. It had been done so because the particular volt and the E.M.F. of the Daniell cell were very closely allied. But if the volt had been made 10^9 instead of 10^8, then their practical unit of current the ampère, would have been exactly the same as the unit C.G.S. that is now nearly always used in enquiries, so he felt quite sure that the day was not far distant when all electricians would have to take into consideration the enlargement of the volt, and it would be beneficial in enlarging the other units at the same time. To take an instance, there was the watt, this was too small to use; as the unit of the power they had to call it the kilowatt, and because it was called that it did not go down so smartly as if it had been called the watt. If they raised the volt to 10^9 they would also raise the watt, then the watt would become very nearly a man power and ¾ of horse power, and they would obtain a unit of power scientifically accurate, and so closely allied to existing units used by engineers in general that the ridiculous horse-power would be driven out of existence, and the watt used instead. With regard to Professor Barker's suggestion as to the name of Franklin, they all agreed that if it was possible to slip in the name they would, but it was not the only name they wanted to slip in, there was Henry which had been suggested in America as the unit of self-induction, he could promise Mr. Barker that if any new nomenclature was wanted the names of Franklin and Henry should receive consideration.

The following discussion took place on Messrs. Lawrence and Harries's paper "On Alternating Currents in relation to the Human Body," and Mr. Wilson Hartnell's paper on "Fire Insurance Rules," published last week.

Mr. PREECE said the two papers read touched upon a question which was at the present time of great importance, that is, the danger to person. The way in which Messrs. Lawrence and Harries had worked at the question from a personal point of view was a right one. They had attacked the question in a scientific manner, very gradually accumulating well assorted facts, and very gradually giving them to understand how the human frame became influenced by the currents, and the result to a certain extent was startling; it was startling to find that alternating currents were so much more painful than continuous currents, and also startling to find that these sensations of discomfort could be produced with such ridiculously little currents. Those who had spent their lives, as he had, in the practical applications of electricity, knew something about the effects of shocks. He supposed, in his career, he must have received a million shocks, or perhaps more; at any rate, when those two gentlemen read their paper before the Institution of Electrical Engineers, he was conscious of the fact that the severe shocks they had experienced were due to such ridiculously low currents. Small as the currents were, they possessed a danger; not that the currents themselves would hurt, but that the reception of a shock would frighten a timid person and probably cause him or her to fall down, and produce, as is often the case, a stoppage of the heart and death from other causes. The subject of the danger of currents was brought up last year at the meeting at Newcastle, and it led to considerable discussion. In the address, he ventured at that time to point out how extremely unscientific and inaccurate any attempt to introduce electricity for executionary purposes was until they knew about its influence, and the result had fully confirmed his doubts of the whole matter, and they had seen that they scarcely knew what they were going to do; and from the papers before them, they had a great deal more to learn before they dared to use electricity for the purpose of execution. There were many points he would commend to the notice of Messrs. Lawrence and Harries before they had thoroughly thrashed out the matter, one in particular was the effect of electrostatic charges on the human frame, and also the effect of self-induction of electro-magnetic apparatus, through the sudden rise and fall of the current. Continuous currents rose very gradually, and did not influence much the human frame, but if a current rose suddenly, they would be certain to get severe and serious shocks. Complimenting the readers on their paper, he did not think the effect of such papers would be to increase the timidity of the public in the use of electricity, because after they had shown the currents were dangerous, it was equally easy to see that they could be absolutely safe, and while an alternating current of 100 volts, with a frequency of 60 or 70, might hurt them very much, there was no reason why they should receive a shock. The dangers could be made simply inocuous by placing the wires out of reach. He could scarcely agree with the views put forward by Mr. Hartnell in regard to the fire office. The rules were made for their own guidance, and not for the benefit of electrical engineers and contractors. He considered Mr. Hartnell had referred sufficiently to the question of bad joints, which was a frequent source of danger in houses in generating heat. Insurance offices, or the majority of them, had acted upon the rules of the Institution of Electrical Engineers, which were carefully drawn up. In conclusion, the speaker drew attention to accidents which might occur through leakage where moisture had fallen.

Sir FREDERICK BRAMWELL was not able to follow Mr. Hartnell in what he would call the basis of his paper. He understood it to deal with a certain size of wire as being competent to carry, and to continue to carry, for an indefinite time, and under all circumstances, a certain current of electricity without the danger of a certain temperature being attained. It seemed to him that the heat would be developed regularly during the interval of time, and the temperature would continue to increase until the dissipation of heat from the surface of the wire was carried off. It was doubtless wrong to give the size of wire to carry a certain heavy current without knowing the incidents of the surroundings of that wire. He would have liked to have taken one of Mr. Hartnell's wires and surrounded it with asbestos and then see what the result would have been. He thought the author of the paper omitted the very important consideration of the surroundings of the wire carrying the current, this should be taken into account. They could take a glow lamp and hold it in one's hand, but if they wrapped it in three or four thicknesses of handkerchief they would set it on fire. Therefore, in all these experiments the considering how far those who made the rules were reasonable in those rules, it was well to bear in mind the circumstances of the surroundings.

Major-General WEBBER referred to the rules drawn up by the committee of the institution, and said this was done to avoid any conflict. They laid down principles and left the bye-laws to be drawn up by the companies. He considered the prominence which had been given to the subject in the *Times* was to a certain extent detrimental to the industry. It made people imagine there was something very mysterious in the dangers likely to arise. Had the dangers of gas been placed before the public in the same way as the dangers of electric lighting, very little gas would have been in use. The rules in existence at the present time were amply sufficient for all purposes. He felt that the use of casing, except in certain cases, would gradually die out. The companies in insisting on casing between floors and ceilings were doing themselves considerable harm. The speaker then referred to the rules published in his British Association paper last year.

Mr. KAPP considered that although the current density rule was a very unscientific one, yet it worked very well in practice.

Dr. HARRIES, in reply to the criticisms passed upon his paper, said the resistance of the body depended on the contact and upon the state of moisture. Smaller currents unusually caused a great deal of pain, the larger one causing unconsciousness so quickly that no pain was felt. He did not propose to enter into the matter of execution, but they had a good deal to learn before they could safely say that a certain current would kill. The recent affair in America was, in his opinion, bungled in a fearful manner.

Mr. HARTNELL replied to remarks made upon his paper, but was indistinctly heard.

TESTING IRON.

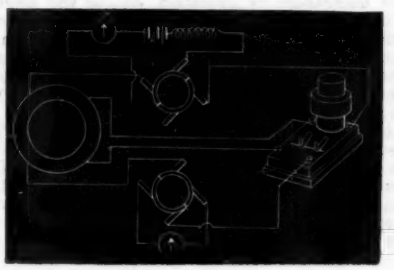
By J. SWINBURNE and W. F. BOURNE.

(*Read before Section A, Leeds, September 9th*, 1890.)

IN practical work iron has to be tested as to its permeability and as to the loss by hysteresis. As regards permeability tests, the ordinary ballistic galvanometer method can, of course, be used; but a ballistic galvanometer is not a convenient instrument, and the method is two slow for practical use. It may, therefore, be of interest to describe the apparatus we use commercially. It is the development of a method devised in 1886. (See *Phil. Mag.*, July, 1887.)

The various samples of iron are obtained in the form of wire, and made up into rings, being wound on a former kept for the purpose, so that all the rings are alike as to dimensions. Before winding, the specific gravity of the iron is taken by weighing, and the specific resistance is measured. The ring is weighed to get the volume of iron, and is then wound with suitable primary and secondary wires.

The arrangement is shown diagrammatically in the annexed figure:—



The circuit from secondary cells is led through an adjustable resistance, then through an ammeter to a commutator, resembling Brillouin's, which is driven by a belt from any shafting that may be near. The circuit is led through the primary to an induction box to the ring under test, and then back to the commutator. The circuit is then led back to the cells. The induction box consists of a primary coil, standing on end, and a number of secondary coils arranged so that the mutual induction is the same for all of

A.

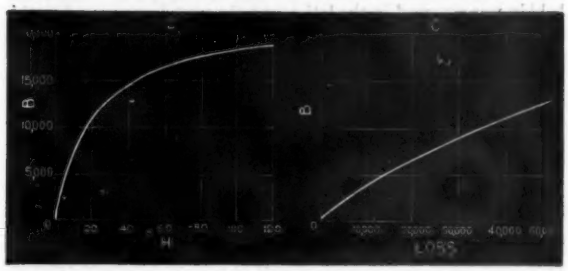
them. The secondary coils are led to buttons, and the switches include them by ones or tens, making the readings in steps of one per cent. of the highest. The primary of the sample ring is in series with that of the induction box. The secondaries are coupled so as to oppose each other, and arranged in circuit with a second commutator; a Varley, or, as it is more often called, a Deprez-d'Arsonval galvanometer, being inserted in the circuit. The two

B.

commutators are, of course, on the same spindle. The adjustment of the induction box was carried out as follows: The coils were roughly calculated to give a mutual induction a little in excess of a convenient round number per turn of secondary. A cylinder of a known diameter with a known number of turns per centimetre in the primary, and a known number of turns in the pilot coil was taken, and put in the place of the sample ring, and its mutual induction measured with the induction box. To allow for the error due to the shortness of the cylinder of the standard coil, it was slipped out of the pilot coil, and moved exactly half its length in a direction along its axis, and a new reading taken. This reading gave the error due to the ends of the cylinder. A shunt was then put across the primary induction box, so as to make the readings come out in microhenrys.

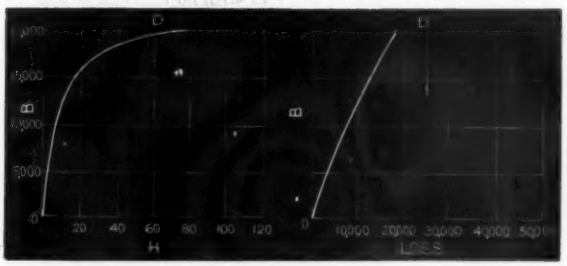
To test a sample of iron all that is necessary is to alter the mutual induction by steps, and to bring the galvanometer to zero for each step by means of the adjustable resistance. As the galvanometer is dead beat the readings can be taken in a few minutes.

The importance of loss by hysteresis in alternate current work is only now beginning to be fully realised. There are several ways of measuring the loss in transformers, but none of them seem satisfactory. Sometimes the transformer is put in a calorimeter, or else it is assumed that the pressure and even the exciting current vary harmonically, and have a so-called "angle of lag." The published efficiencies of most transformers are got by finding the loss from the copper resistances, and neglecting the loss in iron altogether. There is still another method, and that is taking the curves of pressure and current. Prof. Ryan has been singularly successful in this with a modification of Joubert's method.



C.

Tests of transformers by means of lag angles and calorimeters have been published by Profs. Ferraris and Ayrton, and Major Cardew. As the loss in a transformer can be divided into the loss in the copper which varies as the square of the load, and the loss in the iron by hysteresis and Foucault currents which remains constant, these results can be checked. The results published,



D.

as obtained by these experimenters, show inaccuracies that make them quite valueless. The loss in the iron in Prof. Ayrton's experiments varies 160 per cent. of its smallest value, while Prof. Ferraris's cores give out power working as refrigerators. (See article "On Induction and other Things," ELECTRICAL REVIEW, October, 1887.)

There is really little reason for measuring the loss in a transformer; it is much simpler to measure the loss in the iron. No

E.

one would think of measuring the loss in the copper by means of a calorimeter or angle of lag method. All that is needed is to measure the effective current and multiply its square by the resistance, the resistance being determined from the specific resistance of copper, or by direct measurement. Similarly, in the case of the iron, it is best to determine the qualities of the iron once for all,

and then the efficiencies of all transformers made of it can be foretold.

We use the same rings as for the permeability test, but do not employ the secondary wires. The loss of power at various frequencies and inductions is taken with a wattmeter. It is sometimes supposed that a wattmeter cannot be made with little enough self-induction to read accurately. If there is much self-induction in the pressure or shunt circuit, the reading will be lower than that with a direct current if there is no self-induction in the circuit in which the waste of power is to be measured; but if the current is behind the pressure, as in measuring the loss in iron, the wattmeter may even read too high. We therefore designed a special instrument, which was made for us by pupils of the London College of Electrical Engineers. The current coils are fixed, and the moving coil is suspended by a fine wire, with a fine spring at the foot, to take the electricity out again. The moving coil has few turns and little self-induction, and a large non-ductively wound resistance is in series with it. This wattmeter can be read with a mirror, if desired; but with 2,900 ohms in series with the pressure coil, it gives a torsion of 2° per watt on a non-inductive resistance. The series resistance is not wound with a looped wire as is usual in resistance boxes, because this method is not good, the insulation being apt to break down. A single wire was therefore used. When one layer was wound, the bobbin was reversed in the lathe, and the next layer wound in the opposite direction, a thin layer of insulation being put between the layers. This method secures absence of self-induction, and good insulation, as the beginning and end of the coil are kept well apart. The readings are taken by bringing the index back to zero by turning the suspension, so that the mutual induction of the coils is zero, as the coils are at right angles.

The self-induction of the pressure coil was not directly measured, as that would give us no useful information, as we do not know the variation of the current and pressure of air dynamos. They certainly do not vary harmonically, and at full load the pressure rises slowly and falls suddenly in each half period.

The wattmeter was therefore subjected to a severe test. Readings were first taken with direct currents on a resistance; readings were then taken on the same resistance with an alternate current. This resistance had very little self-induction, so that any self-induction in the pressure coil should lessen the reading, by making the current in the pressure coil lag, and also by reducing it. The reading with the alternate current was 2·1 per cent. less than with the direct. This figure is entered in the note-books, but though it is too small to matter in our work, it is larger than it ought to be. The next test was to measure the power taken by a coil with the same current and same pressure, but with no resistance and large self-induction. It is difficult to make up a coil with no iron core to take 50 volts and 10 ampères with no appreciable loss by resistance; we therefore took a hedgehog transformer, and measured the power taken by it. The reading was taken with 50 volts and 4·2 ampères. If the pressure coil had any appreciable self-induction, the reading would be considerable; it might, in fact, be anything up to about 200 watts. The least self-induction would increase the reading enormously. The reading was 11 watts, and the calculated loss by copper and iron in the transformer with only 50 volts on its secondary was 10·3; so the wattmeter is practically correct. Let it be supposed, however, that the loss in iron was really less than this, and that the loss was two watts less than the reading. This is an extreme assumption; but we may see how much such an error would affect our readings of the sample rings. The assumed error is 1 per cent. of the product of the pressure and current. Now, in the case of a closed iron circuit the power is about half the product; so this would lead to an error of 2 per cent. in the loss in the iron. In a closed circuit transformer the loss in iron is, roughly speaking, 10 per cent. at full load, and about 40 per cent., to take a low figure, taken over the day; so that the error would be 0·2 per cent. and 1 per cent. In the hedgehog form the loss in iron is about 1·5 per cent. at full, and 15 per cent. at all day loads; so the errors are ·03 and 0·3 per cent. respectively, which are too small to matter. As a matter of fact, they are much less than the various errors of observation that creep into such work. Measuring the power in an open circuit transformer is also a most difficult case, for the least self-induction then gives rise to the largest error; in measuring the power in a closed circuit ring the errors are less.

We give a number of curves of permeability and of $\int B\,d\,Q$ per cubic centimetre for different samples of iron. These are practically the same as curves of $\int I\,d\,H$; but $\int B\,d\,Q$ seems a better way of writing it, as $\int I\,d\,H$ can scarcely be said to have any physical meaning, and has even had the effect of not suggesting that the reversal involves waste of energy; indeed, it seems to have rather disguised the fact.

In completing these curves some corrections have been made. The wattmeter absorbs some power itself, as the pressure coil circuit is led through the current coils. We might have compensated for this in one of the ways described to Section A by one of us in 1887, but in this case did not think it worth while. The Foucault current losses are also corrected. The losses in the wires themselves can be calculated with rigid accuracy, as explained in a paper on "Transformer Design," which one of us had the honour of reading before Section G last year. There might also be some loss by Foucault currents, due to imperfect insulation between the wires of the core. The insulation is, however, too good to allow this; in fact, the resistance between two wires, about an inch apart, runs into ohms, the measurement being seven ohms in the particular example taken. The losses by Foucault currents are frequently over-estimated by writers on the subject. If the specific resistance of the iron is known, they can nearly always be calculated with much greater accuracy than they can be measured. The loss by the copper resistance is also allowed for in the curves. Though it is generally the practice to give all the steps in a paper like this, we think it better to give the results only; for, though the paper then looks less imposing than if full of curves and calculations, it is more likely to be useful.

We have not yet tested the same sample at very different frequencies to see if there is any time lag. From the comparatively small loss at high frequencies, it is not probable there is any appreciable time lag.

THE EFFECT OF OXIDATION ON THE MAGNETIC PROPERTIES OF MANGANESE STEEL.

By L. T. O'SHEA, B.Sc.

(Abstract of Paper read before Section A, September 9th, 1890.)

WHEN manganese steel drillings are oxidised they become magnetic. The development of magnetic properties being due to removal of manganese by oxidation, &c., to the magnetic properties of the oxide of iron (probably magnetic oxide) formed.

When the oxidised product is reduced in hydrogen the iron oxide is converted into metallic iron and the manganese remains as manganous oxide (Mn O.). The reduced steel is now powerfully magnetic in virtue of the magnetic properties of unalloyed metallic iron.

During the process of oxidation the proportion of manganese to iron oxidised in a given time is only very slightly in excess of the proportion of manganese to iron in the original steel. The excess of manganese oxidised is in all probability due partly to the greater susceptibility of manganese to oxidation, and partly to the heterogeneous structure of the steel.

The following discussion was conjointly on Messrs. Swinburne and Bourne's paper on Testing Iron; Mr. Preece's paper on Magnets, and Mr. O'Shea's paper:—

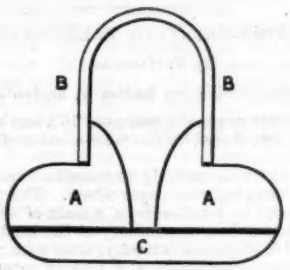
Mr. PREECE said it was his intention to pursue the question of tempering, and he would be thankful for any suggestions. He was going to take a great number of samples of steel, raise them to different temperatures, and quench them in different cooling mixtures, such as oil, mercury, and water.

Prof. BARRETT remarked that he believed the exact temperature at which the heated steel was hardened by quenching, as well as the ratio of quenching, would be found to be important. If quenched short of the recalescent point no hardening ensued, and steel could not be tempered; hence the subject connected itself with the Committee, of which he was secretary, on magnetic and other phenomena connected with the recalescent point in steel. Dr. Ball in a recent paper read before the Iron and Steel Institute, said that both the tensile strength and magnetic properties of steel underwent a constant change when the steel was quenched at a too critical point; one 700° C., and the other about 1,300° C. He hoped Mr. Preece would send specimens of his steel to the recalescent committee. In regard to Mr. O'Shea's paper, Prof. Barrett remarked it was Mr. Hadfield who first noticed that magnetic steel filings became magnetic in heating to whiteness. He had, through Mr. Hadfield's kindness, been able to make many experiments on this question, the results of which he had communicated to the Royal Dublin Society. Mr. O'Shea had shown that oxidation could hardly be regarded as sufficient cause, and he (Prof. Barrett) was inclined to think the cause was due to some dissociation or decomposition of the magnetic steel, whereby free iron particles were liberated. This effect did not occur in wire nor in filings wrapped in platinum foil; but this might be explained by the more rapid cooling which takes place in the filings, whereby the molecular state at a high temperature might be fixed.

Mr. O'SHEA, in reference to Prof. Barrett's remarks on dissociation, pointed out that steel in the mass did not present those magnetic properties to the same extent as it did in the filings, and why should dissociation take place in the filings when it did not in the mass? His point was that oxidation did take place, but in the case of a mass of steel that oxide scaled off and left the metal perfectly free from oxide; whereas in the case of the filings the oxide remained with them, and they remained magnetic; then it was that dissociation took place. When the two were oxidised they first had the oxide of iron exerting its magnetic effect, and then, after reduction, the metallic iron exerted its magnetic effect.

Prof. PERRY said that there could be no more useful work than that which was being undertaken by Mr. Preece and his assistants, and as Mr. Preece subjected all the specimens to the same treatment his test was a fair one. But was this the same in the matter of *tempering*. He gathered that only one English specimen was tempered in mercury, and the Allevard specimen had not been tempered by Mr. Preece. He put it that this was really the important matter. the tempering, and he was glad to think that Mr. Preece intended to go thoroughly into the effect of tempering. Until that was done these results were useless. He (Prof. Perry) had tempered differently three similar specimens of the same steel. One in water, one in a little mercury, and one in a large bath of mercury. The third had an enormously greater retentiveness (he was not sure, but he thought it was three times) than the first.

He had the notion that steel must remain in a magnetic circuit of small magnetic resistance if it is to retain its induced magnetisation. That is, suppose a nearly complete ring of pieces of steel to have been magnetised, the magnetisation would be greatly diminished by taking them apart and replacing them. He obtained his great permanent induction by using the best form of magnet he could think of for that purpose, although it might be useless for all other purposes (fig.) B was a strip of glass-hard



steel, fitted to soft iron pole pieces, A A, C being a well-fitted keeper. The force required to pull off the keeper enabled the induction to be calculated. As the dimensions were great at right angles to the keeper, it was obvious that whether the keeper was on or off there was always extremely little total magnetic resistance.

Sir WM. THOMSON said that Mr. A. Gray and himself had made a large number of experiments in the physical laboratory of the Glasgow University comparing steel from different makers. It was very difficult to get from the same maker constant results. Over and over again the specimens were found to differ exceedingly in magnetic quality from one another by 10 or 20 per cent though alleged by the maker to be as nearly the same as he could make them. On the other hand, they would get a very good specimen, and would ask for one like that, but had very great difficulty in getting what they desired. The specimens could not be too hard, and even when he asked for them to be glass hard, those sent did not come up to what he knew they ought to have. He returned them to be made as hard as they could be made, and only then did he get good results. He was exceedingly glad that Mr. Preece had taken the subject up, and he thought the results would be exceedingly valuable and interesting, not to science only, but to applied science. There was a great career for steel magnets.

Mr. GRAY remarked that the induction obtained by Sir Wm. Thomson and himself was about 12,000.

Sir WM. THOMSON said that they reckoned the standard result for the very best steel used to be 100 C.G.S. intensity of magnetisation per gramme weight; that corresponded to only about 10,000 induction, and he was pleased to see the results put forward by Mr. Preece were enormously better than what was supposed to be obtainable. C.G.S. per gramme was a very convenient way of putting it. In connection with his experiments he multiplied by the specific gravity of steel 7·8, so that 100 magnetic moment per gramme gave 780 magnetic moment per cubic centimetre intensity of magnetisation, and that was the best way of putting it. This was the highest intensity of magnetisation that could be obtained.

THE LINEFF ELECTRIC TRAMWAY.

By GISBERT KAPP.

(Read before Section G, September 8th, 1890.)

THE following is an abstract of the paper read, a fuller description was given in the ELECTRICAL REVIEW for July 4th, 1890.

The conductor consists of bare copper strip or cable, and of iron strip. The latter is galvanised so as to protect it from rusting. It lies on the copper conductor, and both are enclosed in a sealed channel formed of asphalt. The copper conductor rests upon the bottom of a trough made of a succession of glazed tiles, and the cover to this trough is formed by the lower flanges of iron rails arranged in short sections so as to be insulated from each other. The head of one rail reaches up to the surface of the road, the head of the other is cut off, and this rail is therefore completely buried in the asphalt. The surface rail, which may be arranged alongside one of the ordinary tram rails or in the centre of the track, is in electric and magnetic contact with an electro-magnet carried under the car. This magnet runs upon the surface rail on wheels which form its north and south poles. The distance of the wheels is greater than the length of a section of insulated rail, so that successive sections become oppositely magnetised. This causes the iron strip immediately below the magnetised region to be attracted upwards, and thus come into contact for a length of several feet with the under side of the two sectional rails. At the same time the iron strip to both sides of this region remains in contact with the copper conductor, and forms thus an electrical connecting link between the copper conductor and a few sections of insulated rail under the car. The current passes from the surface rail through the body of the electro-magnet (which is insulated from the body of the car) into the motor, and finally into the ordinary tram rails and earth in the usual manner. The electro-magnet is energised by a shunt current obtained from the main conductor, but to provide for the possibility of dropping the strip from some unforeseen cause, there is placed on the electro-magnet a third thick wire coil, which can at all times be energised by two storage cells carried on the car, and thus the strip can be picked up and the main circuit again established if it should have been accidentally interrupted. I may, however, at once state that during some tests which I made on an experimental line of this kind, and which lasted over several days, there has been no need for the picking-up battery, as the current was never lost. The way in which Mr. Lineff makes use of magnetic lines of force to effect the attraction of the iron strip deserves attention. It might perhaps be thought that the most direct, and therefore the best, way of utilising the lines of force would be by one single line of sectional rail, through which there would be longitudinal magnetic flux corresponding with the fore and aft position of the poles, and attraction of the strip at every gap between two sections. Experiment has, however, shown that this apparently direct way is by no means the best way, and that far more satisfactory results can be obtained by arranging a more roundabout course for the lines of force. This is attained by the employment of the subsidiary or buried rail, the gaps in which do not exactly correspond with those in the main or surface rail, but are shifted forward by a certain amount. In consequence of this arrangement, the buried rail acts as a kind of magnetic bridge to successive portions of the surface rail, and this action takes place in two ways, one direct and the other indirect. The direct way is longitudinal, and does not affect the strip at all. The indirect way is both longitudinal and transverse, the latter passing several times through the strip. The buried rail is a rather imperfect bridge to the lines of force traversing it longitudinally, because its magnetic resistance in that direction is great, but this rail forms a very efficient bridge for lines passing through it transversely, owing to its lower magnetic resistance in that direction which includes the strip. The flow of magnetic force transversely is therefore that which effects the attraction of the strip, and may be represented as a series of magnetic stitches passing to and fro between the two sets of rails and the strip.

DISCUSSION.

Major-General WEBBER said they were very much indebted to Mr. Kapp for his description of the system. It was one which, he thought, met, in a remarkable way, a want which had been felt for a long time, assuming, of course, that nothing but underground conductors would be allowed by the authorities. Several engineers of the speaker's acquaintance had been directing their attention to the means of picking up contact in a duct underneath the surface, which contained the copper conductor, and they had, he must confess, fallen short of the ingenuity displayed in the system suggested by Mr. Lineff. The description he had just heard showed that they might see daylight in that direction. He should like to draw the attention of Mr. Kapp to one or two points, on which the meeting was entitled to a little further information. Before proceeding further, the speaker pointed out one or two things, on the diagrams, which were not quite clear. In the main, however, the diagrams gave a most excellent and graphic description of the way in which the magnetic field in the rolling magnet excited the rail. He felt, however, that there was absence of information as to the pressure which actuated the motor in the car. Supposing the pressure to be five volts, he failed to see that it was secure in preventing the rail remaining in contact after the passage of the car travelling at the rate of about 15 miles an hour, not particularly on the lines, but in the subways. Although the people did not walk in the subways, there was still a liability to accident if there resulted a permanent contact between the strip and the iron rails. In the absence of that information, he would also like to ask the size of the copper conductor to the work which requires to be done. He must confess some doubt as to the insulation of the conductor as shown on the diagram. Though it might be fairly good, there was the different condition of highways, &c., and the question of weight, which at some time might break the whole thing to pieces. In conclusion, the speaker referred to the competition between the use of cable and electrical traction, considering there was a large field for work.

Mr. PREECE said he had only to add to what Mr. Kapp had said by stating that he had inspected the working of the system near Chiswick, and he corroborated every word that the reader of the paper had said. His (the speaker's) fears of practical success of the system were, principally, that there might be a failure of contact; but this was got over, first, by having a very broad strip and very lengthy contact, and also by the fact that the flexible iron conductor is galvanised, and, therefore, always clean. Moreover, the galvanisation on the surface has exactly the same effect as the insertion of pieces of paper on the pole pieces of electro-magnets. Of all systems produced, this had an air of practicability about it, but it would be quite impossible to give a definite opinion upon it until it had received the test of actual practice. His impression was that the tramway company which served the district about Kew would lay down three or four miles of the system, and he hoped when they met at Cardiff next year that Mr. Kapp would be able to tell them the results of an absolute practical test.

Prof. ARNOLD LUPTON made some remarks on the insulation of the rails and the falling of the strips, but his remarks were indistinctly heard.

Mr. SELLON said there were one or two questions he would like

to ask. They had not had any detail as to the cost, which was naturally the first thing of a tramway engineer. Although Mr. Kapp had said the system could only be an advantageous system in the particular districts, because no other would be allowed in the districts, he did not see why other electric systems should be thrown out, because Mr. Kapp wished to introduce Lineff's system. He would have been glad if Mr. Lineff had joined hands with them in the late fights in Parliament against telephone companies. If the telephone companies were going to have their clauses introduced into their bills for electric traction, neither Mr. Lineff's system nor any other system by which the return wire coming through earth could be used. One great difficulty he saw with the system is whether the contact is always going to drop directly the car passes over at great speed. He desired before sitting down to draw Mr. Kapp's attention to the telephonic clauses, and he asked the question as to the cost per mile and its absolute efficiency from its generating station at the car motor.

Prof. EWING said how much one must admire the exceedingly ingenious method by which Mr. Lineff had solved the fundamental magnetic difficulty in the problem. They had here a strip of sufficient amount of mechanical force; the action upon the iron strip occurred only when the iron rail above it was interrupted, and if the longitudinal action had been made use of, it would have been necessary to cut a longitudinal rail into an inconveniently large number of sections, but by the exceedingly simple device of employing a supplementary rail cut into comparatively long sections, Mr. Lineff had succeeded in grasping his conductor not at one or two points only, but almost the whole length under the car. It was impossible not to admire, from the magnetic point of view, the exceedingly ingenious solution of the difficulty. Something after the same system had been before the public as a proposal for a number of years—namely, the system originally introduced by Messrs. Ayrton and Perry having a thoroughly well insulated conductor underground, which was to be connected when the car passed with successive sections of a not so well insulated conductor serving as a service conductor. This was exactly what Mr. Lineff did, though, of course, in a very much more satisfactory way than the mechanical methods practised by Ayrton and Perry.

Mr. SWINBURNE wished to emphasise what Mr. Sellon had said. It was an important question that of the telephones, and one hardly knew what would happen unless the thing could be settled. Insulated returns were insisted on, which was a tremendous drawback to electric traction.

Major-General WEBBER said that, with regard to the telephone, they could next year dismiss this fear from their minds, for he had every reason to believe that almost all the telephone systems in this country would be served by metallic returns and not by earth returns, in which case it would not be necessary to insist on such clauses.

Mr. KAPP, before entering into the technical questions, said he would reply to Mr. Sellon. He wished it to be clearly understood he had not any interest whatever in bringing forward the Lineff system. He placed before them the result of careful investigations without comment. He did not wish, as Mr. Sellon had said he wished, to throw out any other system of electric traction; for his part, he would be glad to see it go ahead a little faster. English Town Councils (and they must reckon with the powers that be) would not tolerate the overhead wires, and, consequently they must work with the underground or some other system, and often the Town Council, as was the case in the Hammersmith Vestry, had so tender a regard for cyclists, as to prohibit the use of the slot in the street. The difficulty in disturbing the telephone wires were overcome by working the tram lines on the three-wire system, the down line connected with the positive and the up with the negative, and the third wire put to earth, which resulted in a differential current, which was small, going to earth. He was sorry that he did not explain that the current went back to the station in the usual way; but, of course, they could have a second conductor if they wanted to work a close circuit. The system of duplicating the telephone wires was far preferable. They all knew the bad telephones in London, and they would be better if that plan were adopted. In regard to the question asked by General Webber about the strip remaining in contact, he was sorry he did not make it quite clear; the strip did not remain in contact. He had a fear that the residual magnetism would be enough to heat the strip, and another fear was the main wave under the car, by some way jerking the strip, would induce subsidiary waves and make a contact; but he (the speaker) had tried in many ways to make this contact, but had not succeeded. General Webber evidently thought the contact would be due to the voltage, but the residual magnetism did not prolong the contact, which was the reason that galvanised covering was used. As to the enquiry about insulation, what he had put on the blackboard is the line as it was actually built, but since the line had been finished Mr. Lineff, who had a most ingenious mind, had improved the general arrangement of the surface, and hoped thereby to get a very much higher insulation. As to failure of contact, a part of Mr. Lineff's work was to provide means whereby the strip could be drawn out and a new strip drawn in, if it were found the strip fell down. A gentleman on the left asked how this one-car system could be worked. The system of working tramways most in use was known as the parallel working system. The conductor which brings the current was tapped by each car, which drew off sufficient current to give motive power; but there was nothing to prevent the second car tapping the said conductor. It was a well-known system of tramways, which had been used in many cases. An ascending car would tap off a little more electric fluid, if he might be allowed to use an unscientific term, and a descending car may tap off a little less, or it may give back a little, if the descent was strong enough. As to whether there would be any noise from the strip, there would be absolutely none whatever. As to the question of cost, he knew what Mr. Lineff's estimate was, although he did not know whether it was correct, the cost would be £2,000 a mile, which was a little heavier than overhead conductor, but not much.

COLUMN-PRINTING TELEGRAPH.

By F. HIGGINS.

(*Abstract of paper read before Section G, September 9th*, 1890.)

This apparatus was originally patented 10 years ago, and is now being practically introduced for the transmission of intelligence in this country.

The receiver, which is entirely automatic, consists of a type wheel and frame carrying the paper sheet. The former derives the motive power for its rotation from a train of wheelwork and a weight, and the latter from the battery at the sending end.

The type wheel is displaced laterally, after each print, by means of a screw, and upon completion of a line of printing is released and returned to zero by a spring which has been wound up by the movement of the printing lever.

One train of clockwork is employed, and the motive power for printing, feeding the paper, and traversing the type wheel, is supplied by the printing electro-magnets.

About 20 of these instruments may be introduced into the circuit of a single line of wire, and any number may be worked from one transmitter. The type rotates at any desired speed (from 100 to 150 revolutions per minute), and the same signals operate both the type rotation and the printing, the difference being that the signals for printing are longer than those operating the escapement, in order to afford time for the establishment of the full strength of the current in the circuit, and to overcome the inertia of the comparatively heavy parts of the printing mechanism.

The other operations of synchronising, spacing between lines, &c., are determined by the angular displacement of the type axis with respect to its zero position. The transmitter is driven by an electro-motor, the speed of which is kept uniform by an electrical governor. A counter upon the transmitter announces to the operator when a line of type has been filled. From 1,800 to 2,000 words per hour would be the maximum speed. Five thousand words can be received without attention, and the paper supply is sufficient for the reception of 30,000 words.

THE EFFECT OF DIRECT AND ALTERNATING PRESSURES ON THE HUMAN BODY.

By J. SWINBURNE.

(*Read before Section A, September*, 1890.)

As there seems to be some doubt as to the relative effects of alternating and direct currents, a bridge which measured the resistance of the patient under various pressures was made up. Fuller readings, which agreed with the first as nearly as such very uncertain readings can be expected to agree, were afterwards taken by putting on different pressures and measuring the current; the resistances being calculated. The alternating currents were measured with a non-inductive wattmeter arranged as an ammeter, the pressure being taken with a hot wire voltmeter. The tests were taken from hand to hand, the hands being dry or wet with dilute acid in the case of direct currents, and dry in the case of alternating. It seemed to make little difference in the case of alternating currents whether the hands were wet or dry. There was no need to measure the resistance from hand to foot, as that obviously would depend on the boots worn.

Human Resistances; Hand to Hand..

Current.	Name.	Hands.	Volts.	Resistance.
Alternate	A	Dry	18	950
Continuous	„	Dry	50	8,000
Continuous	„	H_2SO_4	50	3,010
Alternate	B	Dry	10	1,330
Alternate	„	Dry	18	1,110
Continuous	„	Dry	50	6,660
Continuous	„	H_2SO_4	50	1,930
Alternate	C	Dry	18	620
Continuous	„	Dry	50	5,400
Continuous	„	H_2SO_4	50	1,980
Alternate	D	Dry	18	1,090
Continuous	„	Dry	50	10,000
Continuous	„	H_2SO_4	50	16,000
Continuous	E	Dry	50	6,700
Continuous	„	H_2SO_4	50	1,100
Alternate	„	Dry	18	1,300
Alternate	F	Dry	18	750
Continuous	„	Dry	50	3,320
Continuous	„	H_2SO_4	50	1,710
Alternate	„	Dry	54	670

In the above table the direct pressure is always 50 volts. Any of those tested could have taken more than this; but even with 50 volts the discomfort is extreme if the contact is made and broken. The maximum current taken was ·04 ampère by E, whose resistance is low. He could have taken more if available. All the resistances are much lower than those obtained by the usual method of measuring with a bridge and one or two cells. Probably polarisation then interferes.

When the direct current from 50 volts is concentrated in one finger it feels hot, though especially as the current is reduced, there can be no appreciable heat generated.

The most curious thing is the very low effective resistance to alternating currents. The alternating pressure could be regulated by steps of 4·5 volts. Out of the five subjects tested not one except F could stand more than 18 volts alternating, the maximum effective current taken being ·03 ampère. F seems abnormal. He took 54 volts and nearly a tenth of an ampère. D, who has the highest resistance, was the only lady tested. Though, with the exception of F, none of us could take more than 18 volts alternating with a good contact, I have several times touched 600-volt alternating terminals lightly. They were given by a Siemens machine used for "flashing" lamps. Before I took charge of the factory containing it, I am told several of the girls had shocks from the same machine. Spring switches, which demanded both hands to give any current, obviated danger to them afterwards. I have also had a very severe shock from a 100-volt Ferranti. Though 18 volts was as much as we could take, there was no difficulty in letting go.

These results bear out those of Messrs. Lawrence and Harries † as to the relative resistance to alternating and direct currents, but the figures are entirely different. They never found anyone take over 10 milliampères, while F took 90 milliampères alternating, and E, a workman, took 44 milliampères direct, and could have taken more if available.

NEW PATENTS—1890.

13319. "Improvements in electric bells and motors." J. TOWNLEY. Dated August 25.

13337. "Improvements in electrical contacts." G. FORBES. Dated August 25.

13357. "Improvements in electro-motors." A. SIEMENS. Dated August 25.

13358. "Improvements in the means for driving winches and other winding machinery by electrical motors." A. SIEMENS. Dated August 25.

13359. "Improved means for carrying electro-motors on electrically propelled cars or vehicles." SIEMENS BROTHERS & Co. (Communicated by Siemens and Halske, Germany.) Dated August 25.

13371. "Improvements in electric bells and indicators." H. J. HARRIS and W. H. POWER. Dated August 25.

13421. "Improvements in apparatus for working or welding metals electrically, and in the method of effecting the same." W. P. THOMPSON. (Communicated by C. L. Coffin, United States.) Dated August 26.

13485. "Improvements in fittings for electrical glow lamp conductors." W. WHITE. Dated August 27. (*Complete.*)

13525. "Improvements in electricity meters for alternating or interrupted currents." G. HOOKHAM. Dated August 28.

13535. "Improvements in electrical alarms." N. G. THOMPSON and G. H. REW. Dated August 28.

13549. "Improvements in and relating to converters of alternating currents." R. KENNEDY. Dated August 28. (*Complete.*)

13570. "Improvements in and relating to telegraphic apparatus." B. EGGER. Dated August 28.

13635. "Improvements in or appertaining to electric welding." W. P. THOMPSON. (Communicated by C. L. Coffin, United States.) Dated August 30. (*Complete.*)

13636. "Improvements in electric welding." W. P. THOMPSON. (Communicated by C. L. Coffin, United States.) Dated August 30. (*Complete.*)

13683. "Improvements in electric switches." O. ROMANZE and F. W. WHITE. Dated August 30.

13751. "Improvements in electric switches." C. W. HUNTINGTON. Dated September 2. (*Complete.*)

13770. "Improvements in systems of electrical distribution of light and power by means of transformers." W. F. TAYLOR, G. B. LUCKHOFF and E. H. HUNGERBUHLER. Dated September 2.

13774. "Improvements in electrical connections." F. C. DUNAWAY and F. W. DUNAWAY. Dated September 2.

13791. "Improvements relating to compositions and devices for use in the manufacture of filaments for incandescent electric lamps." H. H. LAKE. (Communicated by V. M. Hobby, United States.) Dated September 2. (*Complete.*)

13799. "Improvements in electrical signalling apparatus." H. H. LAKE. (Communicated by the Electric Secret Service Company, United States.) Dated September 2. (*Complete.*)

13845. "Improvements in and relating to the propulsion of tramway vehicles or boats by means of electricity." J. L. HUBER and L. J. MAGEE. Dated September 3.

13886. "Improvements in and connected with the distribution of power by alternating electric currents." J. SWINBURNE. Dated September 4.

13897. "Improvements in apparatus for the safe deposit of milk and other articles; for electrically announcing the same, and for saving and registering time." C. E. KELWAY and A. KAPADIA. Dated September 4.

13905. "Improvements in and relating to the welding of metals by electricity." M. W. DEWEY. Dated September 4. (*Complete.*)

13921. "Improvements in electric lamps." A. SCHANSCHIEFF. Dated September 4.

13943. "Improvements in power conduits for tramways or railways and in electrical connections therefor." C. T. B. BRAIN. Dated September 4.

13987. "An electricity counter." J. RICHARD, F. RICHARD, and G. RICHARD. Dated September 5.

14050. "An improvement in electrical cut-outs." SIEMENS BROS. AND CO., LTD. (Communicated by Siemens and Halske, Germany.) Dated September 6.

14054. "Improvements relating to apparatus for converting alternating electric currents into continuous currents." W. S. RICHARDS and G. B. JAMES. Dated September 6.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1889.

10082. "Improvements in insulating bases for electric switches, fuse blocks, ceiling plates, and the like." G. BINSWANGER. Dated June 20. 8d. The inventor provides china bases with projecting walls vertically disposed on the front, top, or outer surface of said bases, and forms these vertical walls with perforations or holes through which the metal screws are passed for securing the metal conductor. 5 claims.

11046. "Improvements in cores for electrical apparatus and the method of forming the same." W. P. THOMPSON. (Communicated from abroad by The Westinghouse Electric Company, of America.) Dated July 9. 8d. Consists in first stamping from sheets of suitable magnetisable material such as soft iron, plates of the required size and form from which to build up the core; then subjecting the plates to an annealing process which is carried to such an extent that a thin film of oxide is formed over their entire surfaces, and over, also, the burrs or rough edges produced by the stamping process; and afterwards building up the core by placing such plates side by side. 4 claims.

11242. "Improvements in dynamo-electric, magneto-electric, and electro-dynamic machines." SIEMENS BROTHERS & Co., LIMITED. (Communicated from abroad by the firm of Siemens and Halske, of Berlin.) Dated July 12. 11d. Relates to improvements in dynamo-electric, magneto-electric, and electro-dynamic machines, such as were described in the specification to patent No. 1447, of 1881, wherein a continuous current was produced by separate electrical impulses generated immediately after one another at different parts of the machine, that is to say, in different magnetic fields, the number of rotating bobbins in the form of solenoids being different from that of the magnetic fields, so that the former did not all pass the latter simultaneous, but at successive intervals. The present improvements relate to a modified form of the bobbins (which formerly were made as solenoids), wherein these are made of a zig-zag form with radial active and circular inactive parts. 2 claims.

11296. "Improvements in appliances for setting up or taking down electric incandescent lamps." The Honourable H. DUDLEY RYDER and H. E. DOPSON. Dated July 13. 8d. In order to enable an attendant to so place the stem of an electric incandescent lamp into the socket which is to hold it without the attendant having to get into close proximity to the socket, the inventor provides a holder within which the glass of the lamp can be held and be retained by friction to some extent from turning therein. 3 claims.

11332. "An improved material for the construction of bearing surfaces specially applicable to the brushes and commutators of dynamo-electro machines." K. W. HEDGES. Dated July 15. 8d. Relates to the manufacture of a new material for rubbing or bearing surfaces composed of a mixture of carbon and mica or steatite. 2 claims.

11501. "Improvements in the construction of electric fuzes and detonators, and in the method of and appliances employed for manufacturing the same." P. WARD and E. M. GREGORY. Dated July 18. 8d. Has for its object to provide a means of more completely protecting the fuzes from the destructive influence of moisture, heat, climatic and other influences. 3 claims.

† *Jour.* Inst. Elec. Eng., XIX., No. 86. *The Electrician*, April 4, 1890, p. 557

14342. "Improvements in or relating to accumulators or secondary batteries for use in lighting railway carriages and other conveyances by electricity." J. C. MEWBURN. (A communication from abroad by La Société Anonyme pour le Travail Electrique des Métaux, of Paris.) Dated September 11. 8d. Relates essentially to:—1. A trough lined with a vessel of insulating material, and hermetically closed. 2. Accumulator plates having a special appendage either for individual grouping of plate to plate of the same category, or for the grouping of apparatus to apparatus. 1 claim.

14656. "Improvements in electric glow lamps." A. BERNSTEIN. Dated September 17. 6d. The current is conveyed from two platinum wires which are sealed into the glass bulb. From the platinum wires the current passes to the carbon by means of stout conducting wires, which are generally made of nickel. These conductors are bent in such a manner as to almost approach each other at a given point, and they are held rigidly apart by means of a glass or other insulating piece at their lower end, near to the point at which the conducting wires are attached to the platinum wires. A part of one of the conducting wires is hammered out flat, and thereby forms a spring, which has the tendency to produce a contact between the conducting wires at their bent portion. The conducting wires are held rigidly apart at their two extreme ends, first by means of the glass insulating piece, and, secondly, by means of the carbon rod, as long as the latter is intact. If, however, by the action of the current the carbon should be destroyed, then the conducting wire, which is flattened out as a spring, will follow its tension and produce an automatic short-circuit by placing the conducting wires in contact. 2 claims.

17762. "Improvements in electrical switches." F. L. RAWSON and W. WHITE. Dated November 7. 6d. The inventors enclose an electrical switch of any suitable form in a case of metal or other watertight material having stuffing boxes in its sides, through which pass the insulated conductors to the switch terminals. The top of the case is conveniently formed as a cover, which screws on to the lower part with a face and groove for packing to render the joint water or gas tight; in the centre of this cover is a stuffing box through which passes the handle spindle. This handle spindle has the handle attached to it outside the cover stuffing box and inside it is formed so as to engage with the switch contact arm through an insulating piece when the cover is in place; but this coupling is free and is arranged so that the cover with the handle spindle and handle is quite free to be taken off without interfering with the switch contact arm. 1 claim.

18897. "An improved quick-make and quick-break switch for electrical purposes." J. G. S. CUNNINGTON. Dated November 25. 6d. Consists of a lever and spring, which in the first part of their movement are acted upon or controlled by the handle of the switch. In the remainder of their movement the spring acts on the lever to which one end is attached and draws the lever forward independently of the handle of the switch. 3 claims.

19129. "Improvements in electric dry batteries." C. R. BONNE. (Communicated from abroad by H. Meinecke, the younger, of Breslau.) Dated November 28. 4d. Consists in saturating the carbon electrode in sulphate or nitrate of silver, and in bringing it in contact with sal-ammoniac or with other liquid or substance saturated with liquid in order to form chloride of silver, which is deposited in finely disintegrated particles on the carbon. 1 claim.

THE POSTMEN'S STRIKE.

CONCEIVED in frenzy, characterised by indecision and terror, and carried out in anything but a spirit of general unanimity, the postmen's strike appears, for the time being, to have drifted into the leeway of current topics. The variety and chameleon-like changes in these latter-day struggles between capital and labour are, doubtless, responsible for the little notice taken of the terrible position to which the unwise and unhappy postmen now find themselves reduced; but we are glad to note that the subject has not been altogether lost sight of by the Press, close upon 400 men are realising now all the terrible disadvantages and misery of an unsuccessful strike, their position rendered all the more gloomy from the fact that they are reduced to a much lower level than that touched by artisans and tradesmen who adopt similar courses in fighting for the cause of labour.

When the working man strikes, which he does almost invariably as a matter of business and not of sentiment, there is no avenging angel of monopoly to bolt the door for ever in his face, and to enact a decree of commercial banishment against him. Hard as the fight may be, bitter as recriminations oftimes are, yet the character and manhood of the individual are, generally speaking, in no way involved, and on the settlement, successfully or unsuccessfully, of differences between master and man, the old faces and the old hands "go in," and if there is not exactly joy in the manager's office, at all events, there is no desire to indulge in reprisals; and this is as it should be.

Another most important feature is that the tradesman or artisan need not tie himself to any one shop, factory town, or district. His passport is his tool-bag, and his ability as a workman is a certificate which will carry him round the whole wide world.

He makes light often of the fact that he has been a decade, or, perhaps, two, with some respected master. His departure from the old bench means no loss of pay or social position. It may be the result of circumstances over which neither he nor his employer has any control; besides, few good men remain idle long. The master, indeed, may pay him off through slackness of trade or through the closing of contracts. But it may be that the next influx of work will find him back at his bench, if he has not "gone in" elsewhere. Some men, indeed, do not care for permanent situations.

As much is to be learned by travelling, so will intelligent men often find a means of coming to the front in their callings through the experience begotten of a discreet course of changes from shop to shop or from factory to factory.

We mention such matters to show that to the workmen a strike—particularly a local one—is not such a hopeless and heart-sickening ordeal as that through which the postmen who went on strike are now so unhappily going. Many will say that these things were surely palpable to the postmen, or ought to have been made known to them, when they talked of striking. We fear that they were not overburdened with good advice at any stage of their proceedings, and it is best to consider these things as they were and are rather than as they should have been.

As the post office system generally is a huge government monopoly, no such resources as are available to the "working man" fall to the lot of the postman or the letter sorter. It is surprising that the Postmen's Union should have lost sight of this tremendous fact—a fact which, we are quite sure, inspired the utterances of the Postmaster-General when he spoke of the danger that extreme action would engender to the men themselves. Hand in hand with the question of general monopoly goes that of the character of the individual. The action of the 400 strikers may officially be held to have affected and even tarnished their characters. Here we realise fully the effect and power of officialism on the individual. Though few will approve of the postmen's strike, we doubt if they will say that these unfortunate men are any the less manly, honest, and honourable than before. Indeed, we feel that the impulse of their hearts outdid the wisdom of their heads, or that their frenzied zeal overcame their discretion. The eulogies passed on those who showed their "devotion" to the department may be considered as of little value. We refer now to the men at the General Post office, of whom the Postmaster-General spoke in terms of almost unqualified praise. These "devoted," heartless creatures had all along acted as decoys to their less sophisticated comrades—they were the enthusiastic men, the street paraders, the hooters and groaners and those most noisy in calling out "Strike! strike!" at their public meetings. The district men, who comprise almost the entire body of strikers, beguiled by such will-o'-the wisp demonstrations, have now to bear their own sins as well as those of the "devoted" band. The encomiums of the Postmaster-General will not go far to ease the stings of conscience in their loyal hearts; but, possibly, they may have sacrificed even conscience at the altar of "devotion."

For such men few will feel any pity, and it is not too much to say that a large measure of responsibility attaches to their wicked and unmanly conduct.

Taking all these circumstances into consideration, it

is not surprising that great disappointment was expressed on the publication, some weeks ago, of the correspondence between the Postmaster-General and an ex-M.P. on the subject of the re-instatement of the erring and wretched postmen. A few of the younger, the Postmaster-General pointedly said, would be re-instated, subject to certain conditions—and such conditions. The older men were to have no mercy. Their shortcomings, we gather, and those, probably, of the "loyal" section, would be concentrated within themselves, and they would be punished with the utmost severity. This appears worthy of bracketing with the severest samples of Roman law—ancient and effete. Disappointment became greatly accentuated when reports appeared last week of the continuance of what a contemporary called a career of "vengeance," and the dismissal of merely suspected men—postmen and sorters.

The reinstatement of the whole of the already severely punished men would not be regarded by civilised persons as any sign of weakness and indecision in the administration of the General Post Office. That argument is sometimes applied to savages, but never to any race of intelligent and thoughtful people; therefore the Postmaster-General has no need to apprehend any misunderstanding on that score from futurity. We mention this as it is put forward as a reason for making such a great number of examples. There will be no more strikes in St. Martin's-le-Grand, we feel very sure. The Postmaster's argument is best met by reminding him that each case should be settled on its own merits, and his anxiety with regard to the future may be left to the future. Futurity will look after itself, and will be none the worse for a noble example, and one in accord with philanthropic sentiments many times expressed. The objection that there are no vacancies is one that will not hold water, as we heard months ago from a reliable source that the service is greatly under-manned, both in town and in country.

The Postmaster-General has drawn comparisons between the methods of controlling men in the General Post Office and those generally adopted by employers of labour, but no employer of labour possesses the autocracy of a Postmaster-General. No employer of labour could work the social ruin of 400 men because they had participated in a strike, but, strangely enough, a Government monopoly renders this method of commercial excommunication, with its terrible consequences, comparatively easy of fulfilment. Without going into commercial comparisons which might not altogether redound to the credit of the post office, we can still lay a plea for the exercise of that unstrained mercy which "droppeth as the gentle rain from heaven," and we trust it will be taken up throughout the country.

There are those connected with the administration of the General Post Office who, judged by their platform orations and their recent careers are inspired by high Christian sentiments towards all ranks and conditions of men. They have advised their hearers again and again to forgive "even unto seventy times seven." These gentlemen are surely qualified in the fullest degree to urge the Postmaster-General to display largely those grand and divine qualities which go to build up the public and private reputation of a noble-minded English gentleman. No one is more powerful on such subjects than that courtly and soldierly-looking gentleman, the Secretary to the Post Office, and we cannot believe that he would not practice what he has so often and so ably preached. He has now a splendid opportunity of reaping a harvest of heartfelt gratitude.

The Postal Jubilee glory of 1890 will be all the brighter if that "quality of mercy" of which the immortal Bard of Avon has pealed forth such glorious and sublime harmony to the heart and mind, is observed now fully and compassionately to the heart-wrung and sorrow-stricken men who have already received a terrible lesson, and whose thoughtless actions have plunged happy homes and loving wives and relations into an abyss of misery and cruel destitution.

CORRESPONDENCE.

Fire Risk Rules.

I have read with great interest your different articles in the REVIEW *re* Fire Insurance Rules, and I can testify as to the arbitrary measures sometimes resorted to, which makes it every day more apparent that one solid and sound rule should be adopted and rigorously kept by all contractors; an illustration follows why this should be so.

A little time ago I made out an estimate and specified for a certain class of cables which would be guaranteed to have an insulation resistance of 600 megohms per mile. Having previously used a large quantity of this said cable, I knew its good quality; nevertheless, after my estimate had been accepted, my client wished that all the materials should be inspected and passed by a certain well-known fire insurance office. Of course, I gladly consented, never dreaming of the amount of trouble and expense this meant. Their inspector said nothing but Silvertown cables would do, and condemned almost everything that was shown.

Now, every man is guided by his own sense, and all these articles had passed on an installation not insured by the said office, and received a splendid report.

My complaint is this: after a contractor has given a price, not necessarily a low one, and then finds that the fire office requires material so much higher in price, the only thing he can do is to go to his client and tell him or her the price will be so much more than you expected, owing to this interference; in nine cases out of ten they would think otherwise, and throw over the whole thing, saying you give a price and cannot keep it. My question is, Why?

A. J. Howes.

September 15*th*, 1890.

Elmore Copper Company.

I should esteem it a great favour if you would kindly answer the following enquiries in your next issue. Do you know anything about the commercial value of Elmore's process for manufacturing tubes, wires, &c.? Is the company doing any business, and are their articles likely to be adopted and the business to be a success?

Thanking you in advance for any information, I enclose my card and remain

A Young Electrician.

September 12*th*, 1890.

[The process seems to be a valuable one for tubes, cylinders, &c., but we see no advantage over other unpatentable processes for producing high conductivity wire. It is impossible to say what the company is doing other than putting down plant and floating sub-companies, the business should be a success, but is probably much over-capitalised.—EDS. ELEC. REV.]

Permanent Magnets.

The article published in your last issue on above subject involves considerable misapprehension. I beg to submit a few facts on this matter.

The so-called French steels of Clemandot and Marchal are methods of treating magnet steel of any make. M. Clemandot's is by great compression and subsequent magnetising, without any hardening. Under this process, my steel and others gives similar results.

Marchal is a small but skilful magnet maker, who is using English steel supplied by the successor in my French business. This gentleman is now in Sheffield, and tells me he has his own system, both as to the solution employed and the means of regulating the

heat of the steel. He also considers Clemandot's process worthless.

The only French steel I have found employed in instrument work at Paris is that known as "Alevard," which firm also supply finished magnets.

About ten years since I introduced my quality in France, and found no difficulty in competing with the Alevard, as mine was both more easily worked and more powerful magnetically. The same authority informs me that, after M. Charrier's decease, the Alevard mark has been irregular, and though sometimes as good as any, is also at times inferior.

I supplied several of the principal consumers at Paris for years, and since ceding my trade there the same customers have continued to use English steel from my successor.

There are several magnet steels made here now, which give passable results, but a great deal depends on the manipulation of the steel, viz., obtaining the best heat and controlling it, unless the heated magnets are brought in contact with the water at exactly the same temperature there will be great variation in the induction. A recent case occurred where 2¼ times the induction was obtained when the steel was treated in a better way, and from this cause delicate experiments such as those detailed in the article may be largely invalidated.

As scientific men are supposed not to know much about magnetism, it can scarcely be expected that mere steel makers should either. It is surely the province of electricians and chemists to tell us what is wanted, and then it will be our function to produce it.

We have no means of conducting delicate electromagnetic experiments, but must look at it as a matter of the compositions of the material. We employ certain constituents which have been varied in proportion, and have had considerable expense in analyses and test magnets, with the result that what one consumer says is excellent another reports worthless; for instance, one of the marks comes out badly in the experiments of the article, which my friend from Paris says is excellent steel, if properly handled, and that Marchal would make it come out first class. If electricians are not satisfied with the magnet steels as now supplied, let them formulate the composition of a perfect material for the purpose, so that we may know what to produce.

There is nothing said in the article as to the chemistry of the steels; but that is the manufacturer's point of view.

As to English magnet steel having deteriorated, there is, practically, only one French magnet steel, which is certainly not superior, if equal, to several produced here.

I may add that good magnet steels are produced in Styria and Germany; but as those are not alluded to in the article, need not be further noticed.

G. P. Wall.

September 15*th*, 1890.

An Answer of Thanks.

Many thanks for your leading article on my labours. You have declared your adhesion to the main point—"*that there is only one kind of electricity.*" For this adhesion to my theory of electricity I have sincerely to thank you, but in doing so, you must excuse me for doing my duty toward another party. By God's kind hand I had a pious mother, who taught me from my earliest days to put my trust in God and His promises, one of which is, "Commit thy works unto the Lord and thy thoughts shall be established" (Prov. xvi., 3); another is, "Trust in the Lord with all thine heart and lean not unto thine own understanding; In all thy ways acknowledge Him and He will direct thy paths (Prov. iii., 5). I trusted in these promises and God has graciously fulfilled them in my case. He has made you the instrument of giving me the opportunity of thanking Him publicly for the gracious fulfilment of His promise. In making this public declaration of religious principle in your columns, I am well aware that by doing so I will arouse a spirit of opposition in the minds of some who will assert that your journal is devoted to the promotion of science and not religion. I would therefore shut their mouths by pointing out that we now live in very exceptional times. In my young days no journal devoted to politics and secular matters would admit into its columns religious subjects, but now all this is changed; the secular press is now full of articles bearing on religious subjects, so much so, that some have asserted "that the press has taken the place of the pulpit;" but alas, the great body of the semi-religious articles in the secular press are against true religion, and either openly or disguisedly favour superstition in one form or another. Now the main object of your journal is the promotion of the science of electricity, and one of the forms in which we see electricity is that of light. Now, concerning the origin of light, we have the clearest possible statement in the Bible: "God said 'Let there be light, and there was light'" (Gen. i., 3). Herein we have the positive information that light and consequently electricity came into existence instantaneously; they were created by the command of God. It is a distinct intimation that they did not come by the God-defying dogma of *evolution*. This is a grand subject. I hope all the electricians who read this will in the future, by their words and writings, keep unsullied this God-given foundation of the science of electricity. I now turn to the secular part of the subject, as you have given your adhesion to the main point, "*that there is only one kind of electricity*," and consequently that there is no foundation in fact for Faraday's assertion that there are two electricities or powers. I defer, for the present, noticing your remarks wherein you differ from me concerning the results of some of my experiments, as I am at present preparing to make some new experiments which I have reason to believe will throw still more light on the subject.

James Johnstone.

September 16*th*, 1890.

The Electric Light at Bath.

In your issue of September 5th, I noticed in the form of a leaderette, extracts from a letter written by Charles Powell, who I conclude imposed upon you by stating that he "recently had a run down to Bath," and that he "met the police going to the station to report lamps out and went in with them," &c. These statements are utterly untrue, as this person, instead of being the impartial looker-on that he would have you suppose, was actually in my employ at the time he professes to have visited the Bath Central Station, and working in the engine-room as driver of one of the engines, and was summarily discharged by me for savagely assaulting the second engineer, who had upbraided him for his negligence, which resulted in a breakdown and temporary extinguishment of the lights. Your contemporaries, the *Electrician* and the *Electrical Engineer*, have been imposed upon by the same person and published similar information, but, unlike yourselves, the *Electrician* had the fairness to give the name of their informant, and, had it not been for their very properly doing this, I should have been unable to expose the low cunning of this man, who when leaving here intimated to my staff that he would have his revenge for being dismissed, hence his communications to the technical press. I regret that you should have published as apparently facts, the statements of a discharged *employé* who appears to be as unscrupulous as he is vindictive.

H. S. Massingham.

September 16*th*, 1890.

[We are pleased to insert Mr. Massingham's letter, but his ideas of fairness are peculiar. It is not generally considered etiquette in journalism to give the names of those who supply information, and there was nothing to show that the news sent to us was in any way erroneous.—EDS. ELEC. REV.]